Variable Speed Motor Control

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A COMPARATIVE STUDY OF

VARIABLE SPEED MOTOR CONTROL

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A COMPARATIVE STUDY OF VARIABLE SPEED CONTROL.

There has been for a number of years and imperative demand for variable speed motors for the direct driving of machinery. It is the general opinion that the great bulk of machinery in the future is to be driven by electric motors rather than belt drivers. There are a number of important conditions that are essential and which must be met in order that variable speed motors shall come into general use. Among these may be mentioned: nonsparking under excessive loads; large range of speeds; speed to be constant at all loads where adjusted to any desired speed; compactness; simple mechanical construction; reversibility; lightest possible weight; and high efficiency under average loads.

The different methods by which variable speed of motors is obtained are as follows:-

1st. Rheostat in the armature circuit.

2nd. Rheostat in the field circuit.

3rd. Combination of 1st. and 2nd.

4th. Multivoltage system.

5th. Variations of air gap, or variation of magnetic reluctance in the field circuit.

6th. Interpole method.

By introducing a variable resistance in the armature circuit, thus controlling the voltage impressed on the armature terminals, a variation in speed from zero to a maximum may be obtained. But this is a very wasteful method, and, furthermore, for a

for a given position of the rheostat the speed will vary according to the current consumed. If the torque required of the motor is increased, the amperes will increase and the speed will diminish, although the rheostat position remains unchanged. The large loss of power due to the rheostat, the C^2R loss, is a dead loss, and the rheostat, which is usually of large proportions, make the method inefficient and undesirable.

The method of introducing resistance in the field circuit is far more efficient, involving only the very slight loss of the shunt adjusting rheostat. As the current is decreased the field is decreased, and the C. E. M. F. in the armature is decreased. As the C. E. M. F. of the armature decreases the current flowing through the armature will increase, causing an increase of speed. The objection to the method is that violent sparking at the commutator is encountered with a variation of speed of from 30% to 40% above normal.

The multi voltage system supplies the motor with a number of voltages necessary to obtain the range of speed. The range in voltage may be obtained by means of a number of generators in series: a large generator and a set of boosters: or a storage battery with an end cell switch. This method is efficient for all ranges of speed and load, but requires complicate wiring and accessories.

The variation of magnetic reluctance in the field circuit is obtained by two methods. First, by a movable soft iron core.

in a hollow pole-piece. Second, by withdrawing the armature from the influence of the field poles. This method is superior to any of the preceding in that a wide range of speed is obtainable, good efficiency at ordinary loads, and requires little apparatus outside of the motor itself.

The interpole method of speed variation employs an ordinary shunt motor, between the poles of which are placed auxiliary poles, the windings of which are in series with the armature. The speed is controlled by a rheostat in the shunt field circuit. The method is simple and highly efficient.

Embodying the essential features of the foregoing methods except the multi-voltage system, three motors were obtained on which to work. These were the Stowe, Lincoln and Interpole, which are successful, variable speed motors now on the market. On each of them a test was made which enabled us to make a comparative study of the qualities essential to successful variable speed control.

The Inter-Pole Motor is essentially a shunt motor obtaining speed variation by means of a rheostat in field circuit. It has, however, one or two unique features of construction added by means of which a large range of speed is obtainable. One of these features is the increase of the segments in the commutator, thus cutting down the reactance voltage, and the other is the introduction of auxiliary poles which are located between the main poles. These poles are small compared with the main poles and are provided with coils connected in series with the armature. Owing to this latter fact weakening of the field on [illegible]

produce the required compensatory field of commutation independent of the main field which is decreased as the speed is increased. The effect of the auxiliary poles is the same regardless of the direction of the rotation, because when the current is reversed in the armature it is also reversed in the auxiliary poles. Points in favor of this motor are its simplicity, its compactness and absence of accessories. The armature is carried on ball bearings, thereby reducing friction to a minimum.

The Lincoln motor is an ordinary shunt motor, the shunt field winding being connected in series. Speed variation is obtained by withdrawing the armature from the influence of the field poles. As the armature, which is slightly conical in shape, is withdrawn the magnetic resistance, due to increase in air gap, is increased, thereby decreasing the useful magnetic flux and thus increasing the speed. Special commutating poles are provided under the face of which the armature comes as it is withdrawn into its positions of high speed. The full field strength is used for all speeds, thereby eliminating the undesirable feature of field distortion.

A hand wheel is used in connection with a screw mechanism to move the armature laterally and by means of this wheel it is possible to get an infinite variety of speeds from the lowest to the highest. The magnetic pull of the armature is carried on ball thrust bearing, which reduces all friction. The brushes

are carried by the thrust bearing, armature and commutator all move together, and there is no relative lateral motion between the commutator and the brushes.

The Stowe motor is a shunt motor having pole pieces the cores of which are movable. The poles are composed of a pole shoe of common form integrally connected with a cylindrical shell, over which the magnetizing coils are wound, and with which is a solid core of high permeability and of cross section relatively large as compared with the conducting area of the inclosing shell. By means of a hand wheel this inner core is adjustable in any direction radial to the center of the armature, and is so proportioned that a slight variation in its position within the magnetized shell produces a considerable difference in the reluctance of the magnetic circuit of which the plunger forms a part. When the plunger is so adjusted that the inner end comes in contact with the pole shoe the magnetic circuit is most complete and of minimum reluctance, and since the magnetomotive force remains constant the volume of the magnectiv flux becomes a maximum and the speed a minimum or normal. As the plunger is drawn away from contact with the pole shoe ~~the air gap~~ a column of air is interposed which gradually increased the reluctance of the magnetic circuit as long as the plunger continues to be withdrawn. As the plunger is moved the gap between the pole face and the armature remains constant, the air gap inside the pole being the one which is varied, and the design of the pole piece and plunger is such that

as the total effective magnetism is diminished by outward movement of the plunger the remaining magnetic flux is forced more and more in the direction of the pole tips, thus furnishing a magnetic flux at all times of sufficient strength to insure sparkless commutation.

The apparatus used for the tests were an armature and field ammeter, a voltmeter for the main line voltage, and a tachometer voltmeter. A load was applied to the motor by means of a Prony brake upon a flanged pulley. The power supplied to the motor under test was developed in a 15 H. P. Westinghouse generator, driven by a direct coupled Crocker-Wheeler motor. The E. M. F. impressed on the motor terminals was kept constant at 110 volts by varying the speed of the generator. A small set of scales were used with graduations to 1-50 of a pound.

The first set of runs was taken with the lowest rated speed, as indicated on the name plate. The load was increased from zero to about fifty per cent over load. During these runs readings were taken of the armature current, field current, tachometer and scale, and from the data obtained the developed horse power (D. H. P.); the electrical input and the efficiency were obtained. By adding the armature and field current and multiplying by the constant voltage of 110 volts the electrical input was obtained. The D. H. P. was obtained from the equation.

$$D. H. P. = \frac{2\pi n l w}{33000}$$

Where n = r. p. m.: l = brake arm: [illegible] = [illegible] .— ~~[illegible]~~. Efficiency can then be [illegible] the following equation:

$$\text{Efficiency} = \frac{746 \times \text{B. H. P.}}{\text{El. Input}} \; [illegible]$$

The above set of data was taken on the three machines and tested in both directions of rotation. Then the [illegible] was raised to the middle value, and then to the highest value, and a similar set of runs were made.

The data was tabulated on separate sheets, a check test being made of each. In the induction motor each run had speed and efficiency curves plotted. In the [illegible] the average of the two runs were plotted.

Another test made upon the motors was with the B. H. P. output kept at a constant value and the speed was [illegible] varied. Full rated load and half load runs were taken in both directions of rotation on each of the motors. From this test we were able to obtain an idea of the efficiency of the various machines under load, with variation of speed.

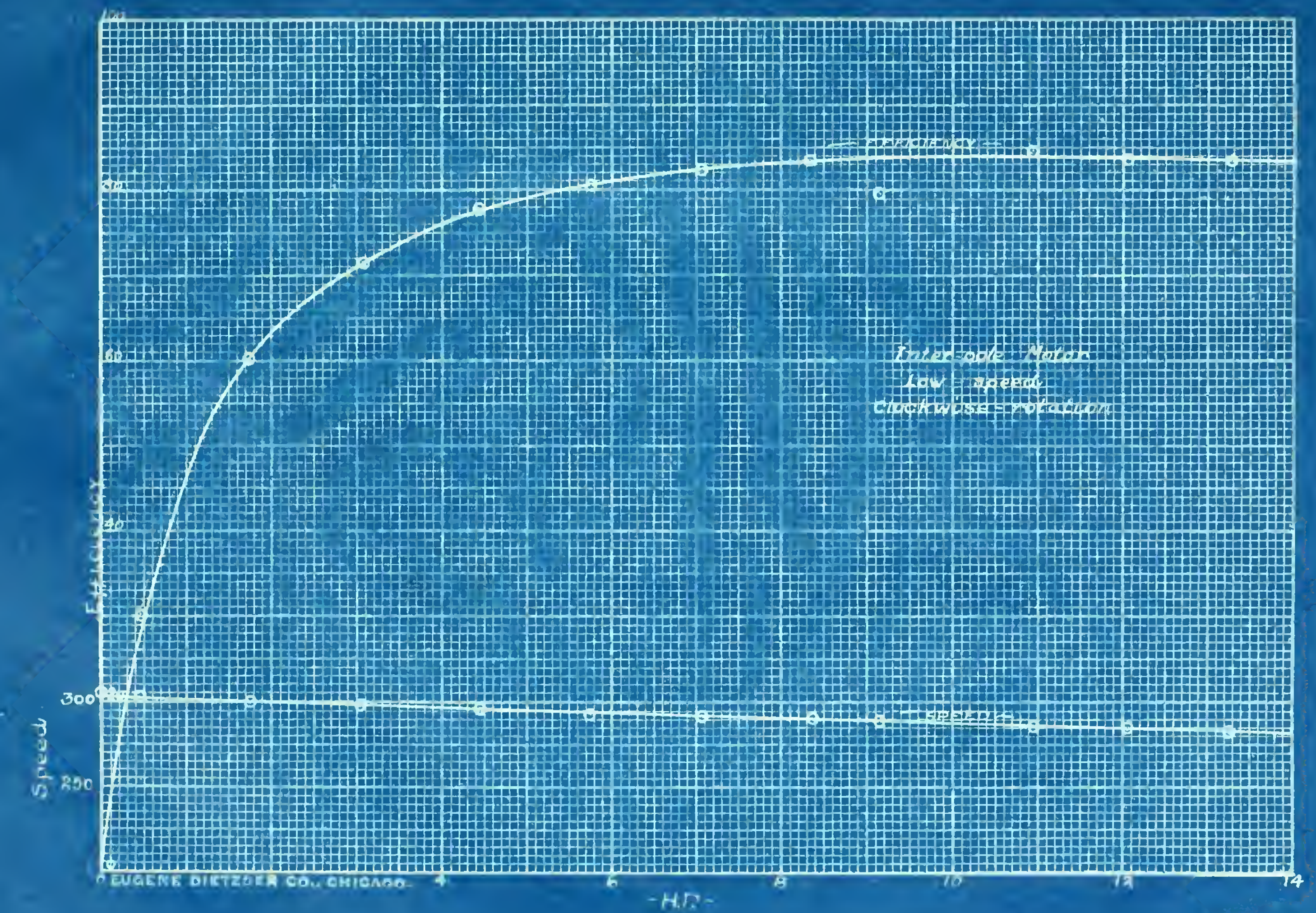
Interpole Motor.

Low Speed. Clockwise Rotation.

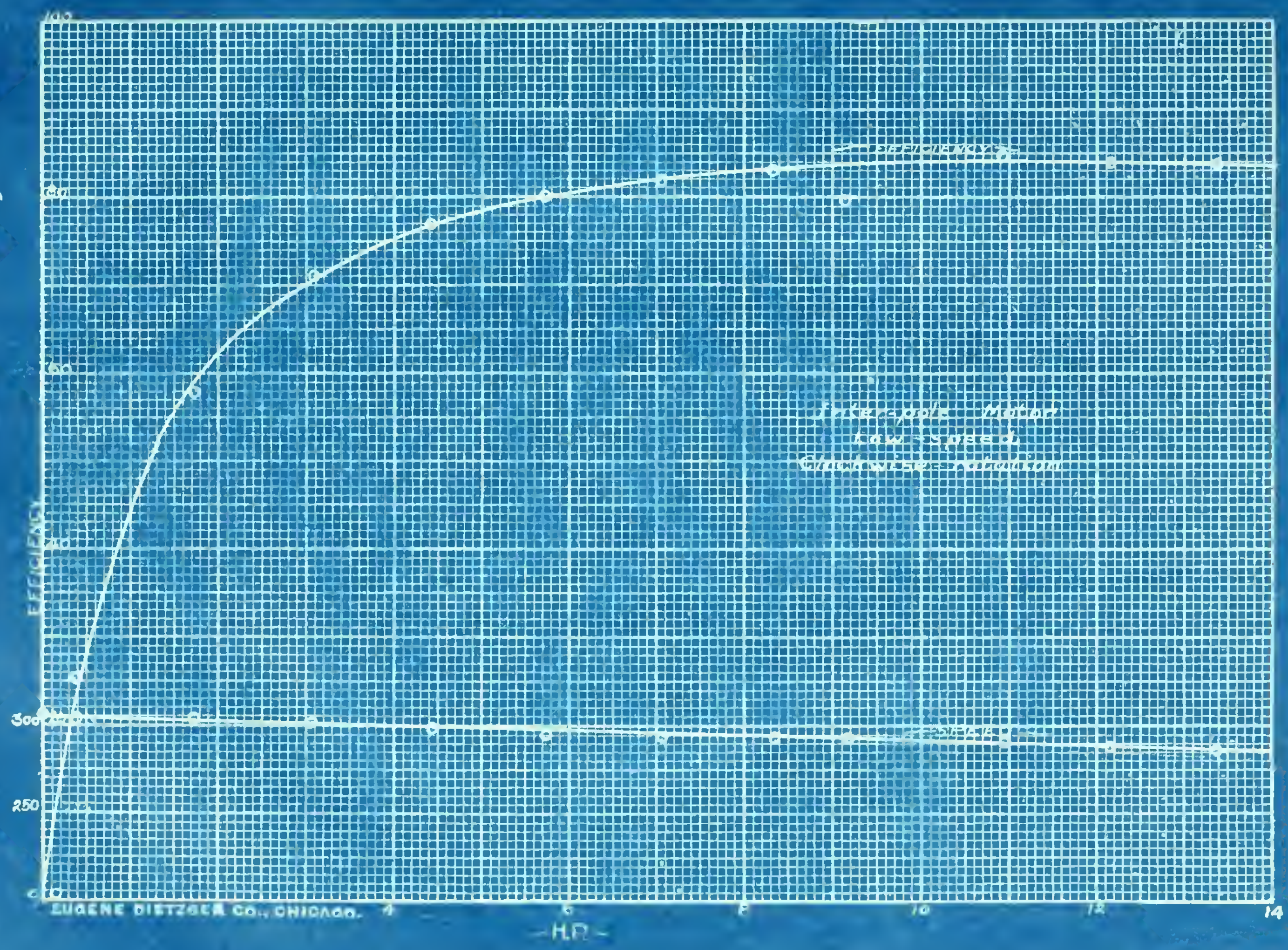
Ia.	If.	Watt Input.	Speed.	Wt.	H. P.	Eff.
5.0	4.435	1154	306	[illegible]	.43	[illegible]
15.0	4.37	2124	304	14.3	1.71	[illegible]
24.6	4.35	3178	300	26.3	3.03	[illegible]
34.1	4.33	4233	[illegible]	[illegible]	[illegible]	75.
45.8	4.3	5339	295	50.	[illegible]	[illegible]
55.3	4.33	6733	294	[illegible]	7.0	[illegible]
65.5	4.3	[illegible]	293	74.	[illegible]	[illegible]
77.3	4.34	[illegible]	291	83.3	9.15	[illegible]
87.3	4.29	[illegible]	290	[illegible]	10.92	72.
95.9	4.31	10751	[illegible]	110.3	12.09	[illegible]
104	[illegible]	11369	[illegible]	[illegible]	[illegible]	[illegible]
115.	[illegible]	13112	[illegible]	134.0	14.50	83.5
123.1	[illegible]	14355	286	[illegible]	[illegible]	[illegible]
133.4	[illegible]	15436	281	[illegible]	17.	[illegible]

Ia.	If.	Watt Input.	Speed.	Wt.	H. P.	Eff.
2.5	4.30	750	[illegible]	0.	[illegible]	0.
7.7	[illegible]	1096	306	[illegible]	[illegible]	[illegible]
10.	[illegible]	2227	304	14.3	[illegible]	[illegible]
24.7	[illegible]	3123	[illegible]	26.8	[illegible]	[illegible]
34.7	4.22	4371	296	[illegible]	[illegible]	[illegible]
44.3	4.2	5505	295	50.	[illegible]	[illegible]
54.2	4.1	6421	294	62.3	7.04	[illegible]
64.0	4.17	7406	292	74.	8.52	[illegible]
75.3	4.13	8554	292	86.8	9.15	[illegible]
85.5	4.24	9618	290	98.	10.	84.
94.1	4.11	10603	287	[illegible]	12.12	[illegible]
105.	4.10	12010	286	[illegible]	13.	[illegible]
116.0	4.095	13310	286	134.8	14.6	[illegible]
127.3	4.060	14504	284	14 .9	16.0	81.7
139.5	4.05	15790	184	15 .3	17.	[illegible]

E--110 Volts



Inter-pole Motor
Low speed
Clockwise rotation
Efficiency
Speed
H.P.
300
250
80
60
40
4
6
8
10
12
14
EUGENE DIETZGEN CO., CHICAGO.


Inter-pole Motor
Low Speed
Clockwise rotation
EFFICIENCY
SPEED
EFFICIENCY
100
80
60
40
300
250
0
4
6
8
10
12
14
-H.P.-
EUGENE DIETZGEN CO., CHICAGO.

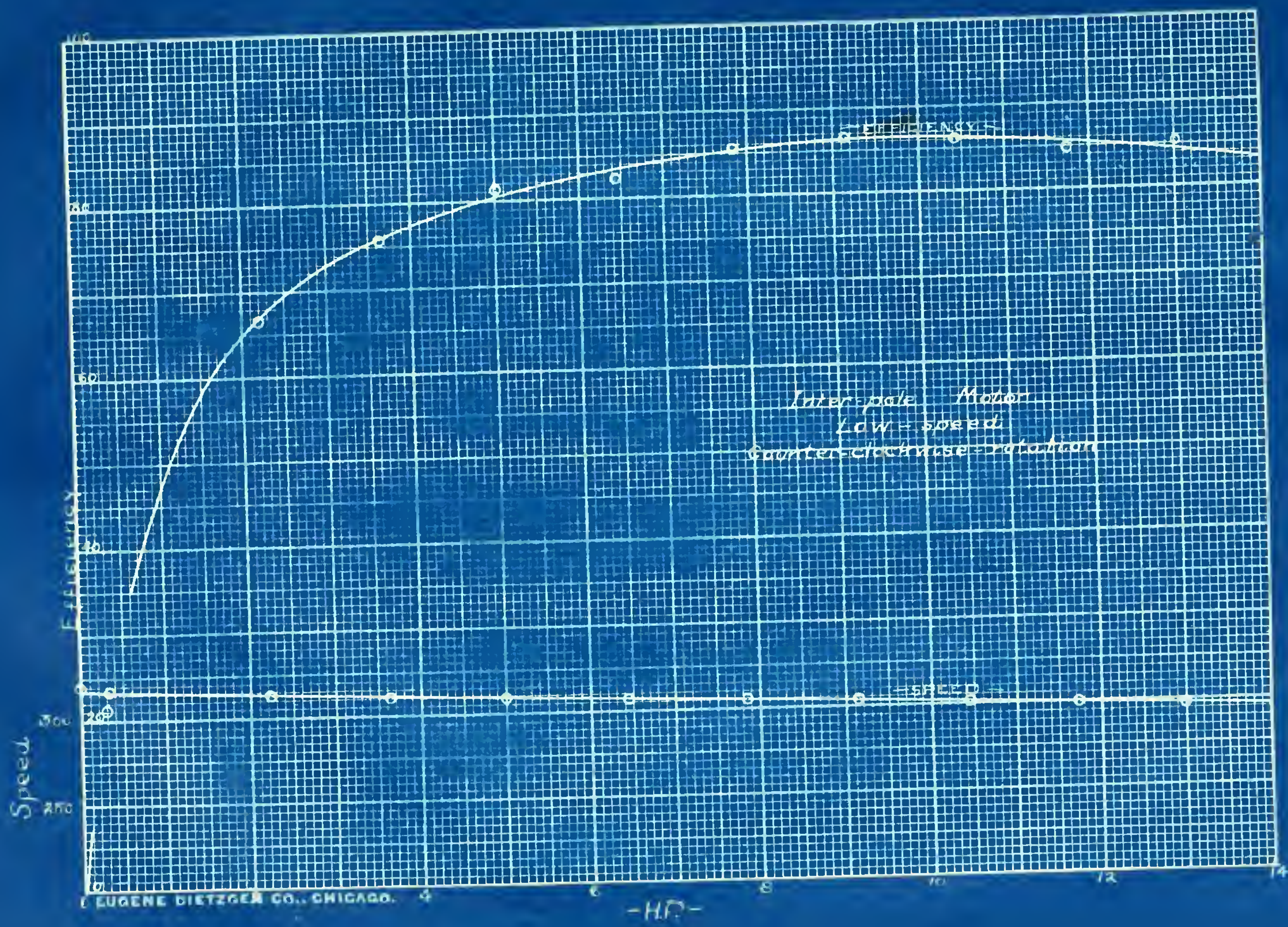
Interpole Motor.

Low Speed Counter Clockwise Rotation.

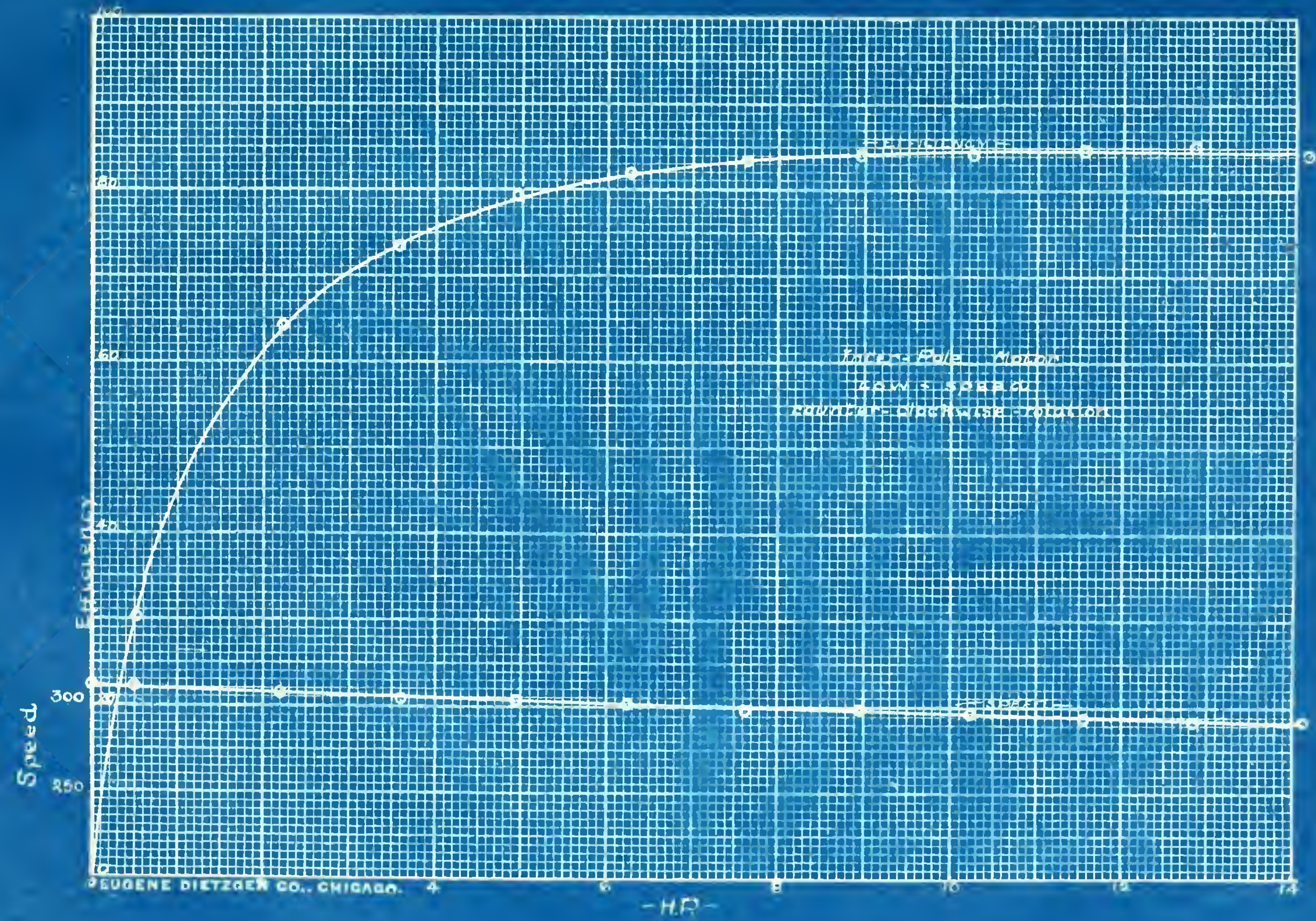
Ia.	If.	Watt Input.	Speed	Lb. Ft.	H. P.	Eff.
88;						
3.0	4.24	796	320	0.0	0.	0.
6.7	4.23	1210	319	4.2	.5	30.8
18.6	4.22	2710	306	[illegible]	[illegible]	[illegible]
28.4	4.20	[illegible]	304	30.8	3.57	[illegible]
38.0	4.20	4342	304	42.8	4.97	[illegible]
47.7	4.19	5707	301	54.8	6.28"	[illegible]
57.4	4.18	6773	298	66.8	7.61	[illegible]
67.5	4.17	7884	297	78.8	8.44	[illegible]
77.4	4.17	8972	296	90.8	10.34	84.
87.2	4.14	10047	295	102.8	11.51	84.7
97.4	4.13	11168	293	114.8	12.87	[illegible]
109	4.12	12445	292	126.8	14.12	[illegible]
119.2	4.09	13561	291	138.8	15.2	84.0
130.5	4.08	14803	289	150.8	16.06	84.5
142.	4.06	16066	288	162.8	17.89	82.2

3.2	4.19	813	321	0.	0.	0.
5.8	4.18	1097	318	6.6	.315	21.4
18.8	4.15	2491	313	18.8	2.24	[illegible]
28.6	4.14	3301	312	30.8	3.66	77.6
37.8	4.12	4611	309	42.8	5.05	81.7
48.8	4.11	5830	306	54.8	6.42	82.5
57.7	4.10	6728	305	66.8	7.78	[illegible]
67.5	4.09	7874	304	78.8	9.13	[illegible]
78.4	4.07	9071	301	90.8	10.4	86.0
89.9	4.06	10335	300	102.8	11.74	84.8
100.	4.05	11445	299	126.8	14.45	[illegible]
123.3	4.04	14007	295	138.8	15.6	[illegible]
135.5	4.01	15546	292	150.8	16.3	[illegible]

E--110 Volts



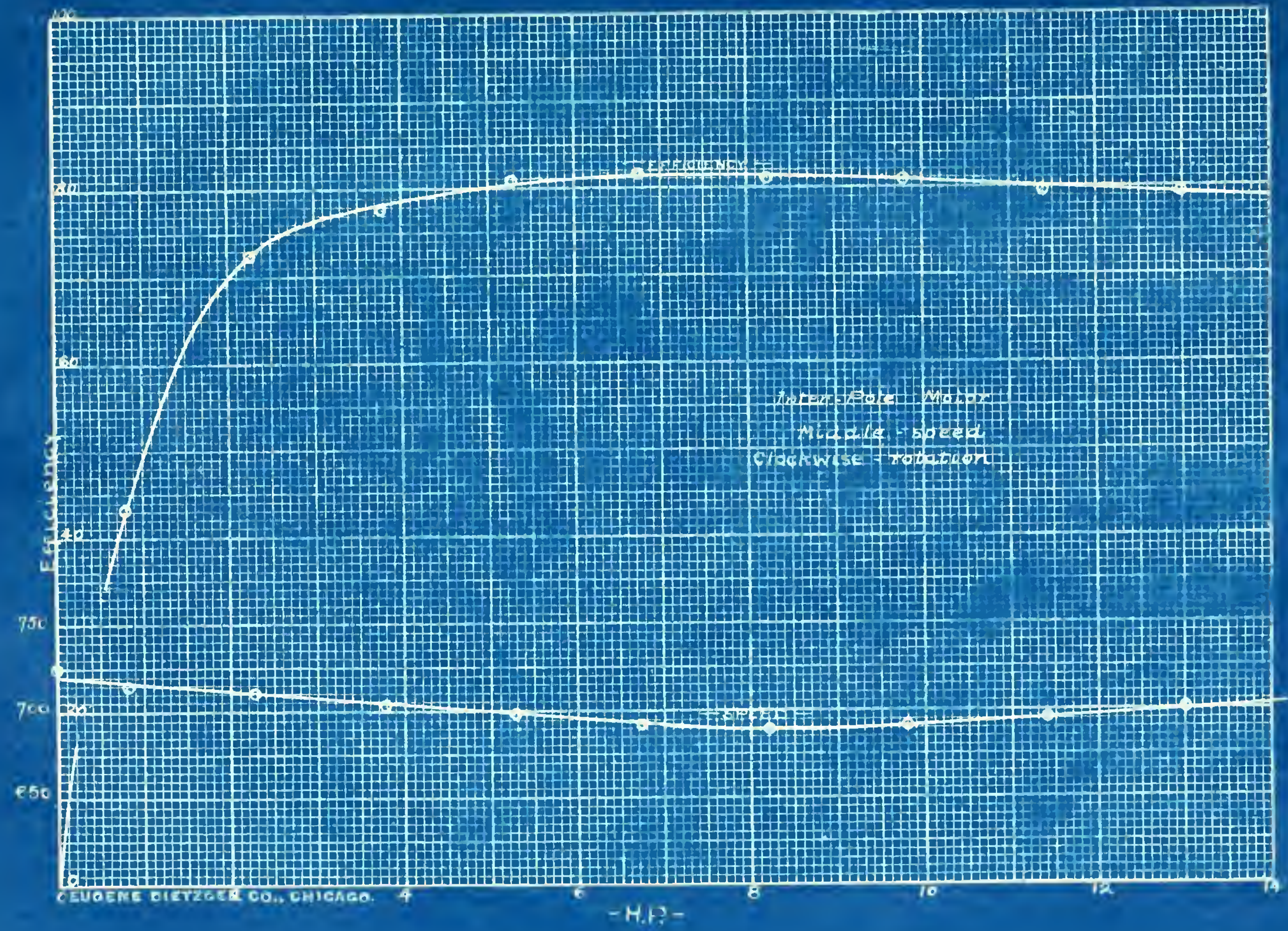
Inter-pole Motor
Low-speed
Counter-clockwise-rotation
EFFICIENCY
SPEED
Efficiency
Speed
100
80
60
40
20
300
280
0
4
6
8
10
12
14
-H.P.-
EUGENE DIETZGEN CO., CHICAGO.

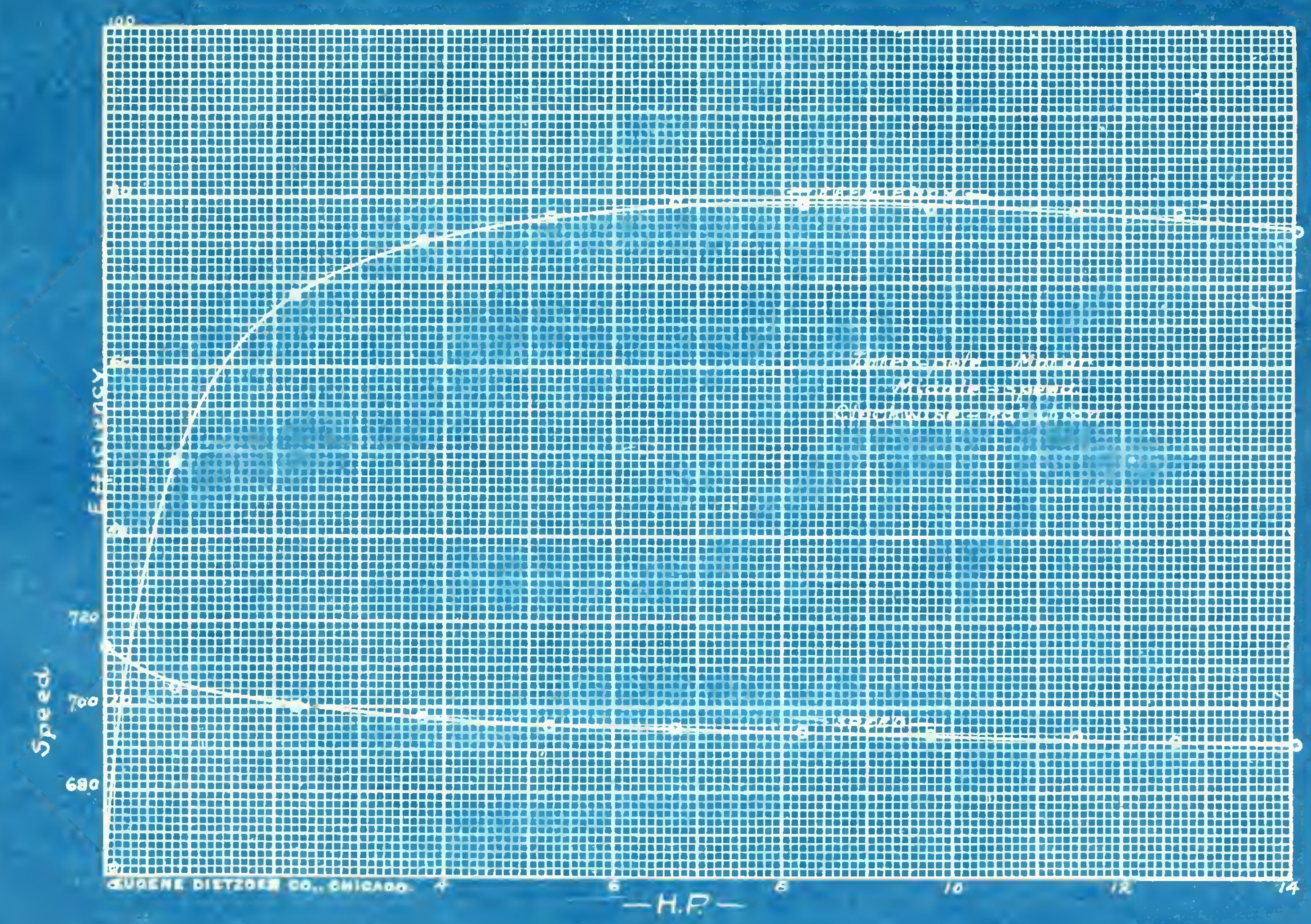

counter-clockwise rotation
Efficiency
Speed
300
250
4
6
8
10
12
14
- H.P. -
EUGENE DIETZGEN CO., CHICAGO.

Interpole Motor.

Ia.	If.	Middle Speed Watt Input	Clockwise Rotation. Speed	T.	H.P.	Eff.
3.3	1.26	380	725	0.	0.	0.
11.5	1.26	1361	713	3.1	.507	4[illegible]
20.1	1.26	2340	710	8.8	2.28	72.4
31.7	1.26	3325	702	14.8	3.78	77.[illegible]
43.0	1.26	4368	697	20.8	5.28	81.
55.0	1.26	6166	692	26.8	6.73	[illegible]
67.3	1.26	7374	687	32.8	8.2[illegible]	[illegible]
80.9	1.26	9003	688	38.8	9.79	80.[illegible]
93.0	1.26	10393	697	44.8	11.4	79.6
109.5	1.26	12183	702	50.8	13.01	79.[illegible]
123.6	1.26	13734	702	56.8	14.53	79.1
139.7	1.26	15503	707	62.8	16.2	77.[illegible]
10.4	1.24	1290	714	0.	.83	4[illegible].6
21.1	1.24	2457	704	3.2	2.26	[illegible]
33.	1.24	3766	690	8.8	3.78	74.[illegible]
44.8	1.24	5034	6.94	14.8	5.26	77.[illegible]
56.7	1.24	6373	690	20.8	6.75	79.1
69.4	1.24	7770	688	26.8	8.24	79.0
82.5	1.24	9211	686	32.8	9.72	78.7
98.0	1.24	10916	685	38.8	11.46	78.3
110.	1.24	12236	683	45.2	12.69	77.5
124.9	1.24	13875	680	50.8	14.1	78.0
140	1.24	15536	678	56.8	15.52	74.5

E-110 Volts


Inter-Pole Motor
Middle - speed
Clockwise - rotation
EFFICIENCY
SPEED
Efficiency
100
80
60
40
20
750
700
650
0
4
6
8
10
12
14
- H.P. -
EUGENE DIETZGEN CO., CHICAGO.



Efficiency
Speed
720
700
680
4
6
8
10
12
14
— H.P. —
EUGENE DIETZGEN CO., CHICAGO.

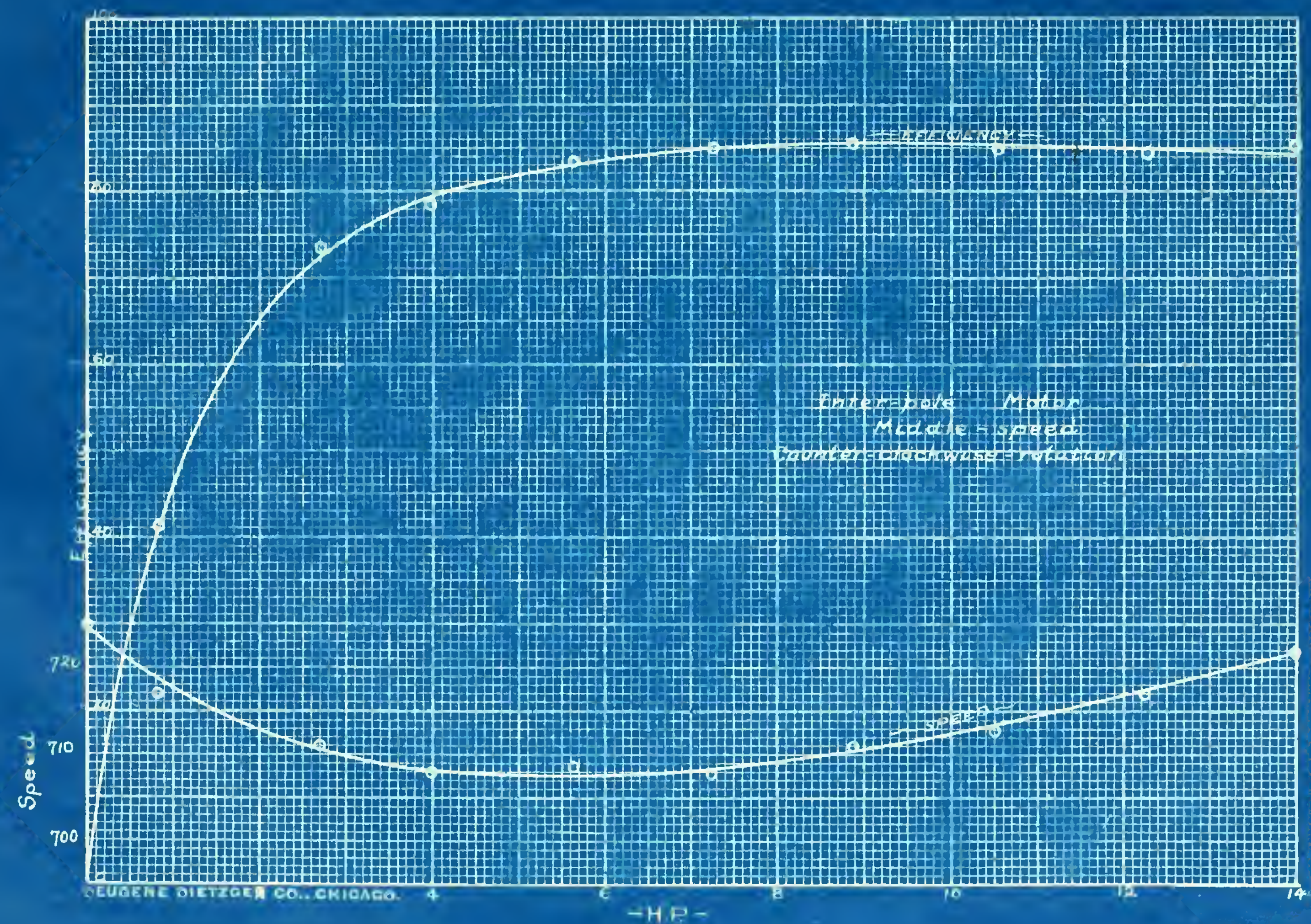
Interpole Motor

Middle Speed C. Clockwise Rotation

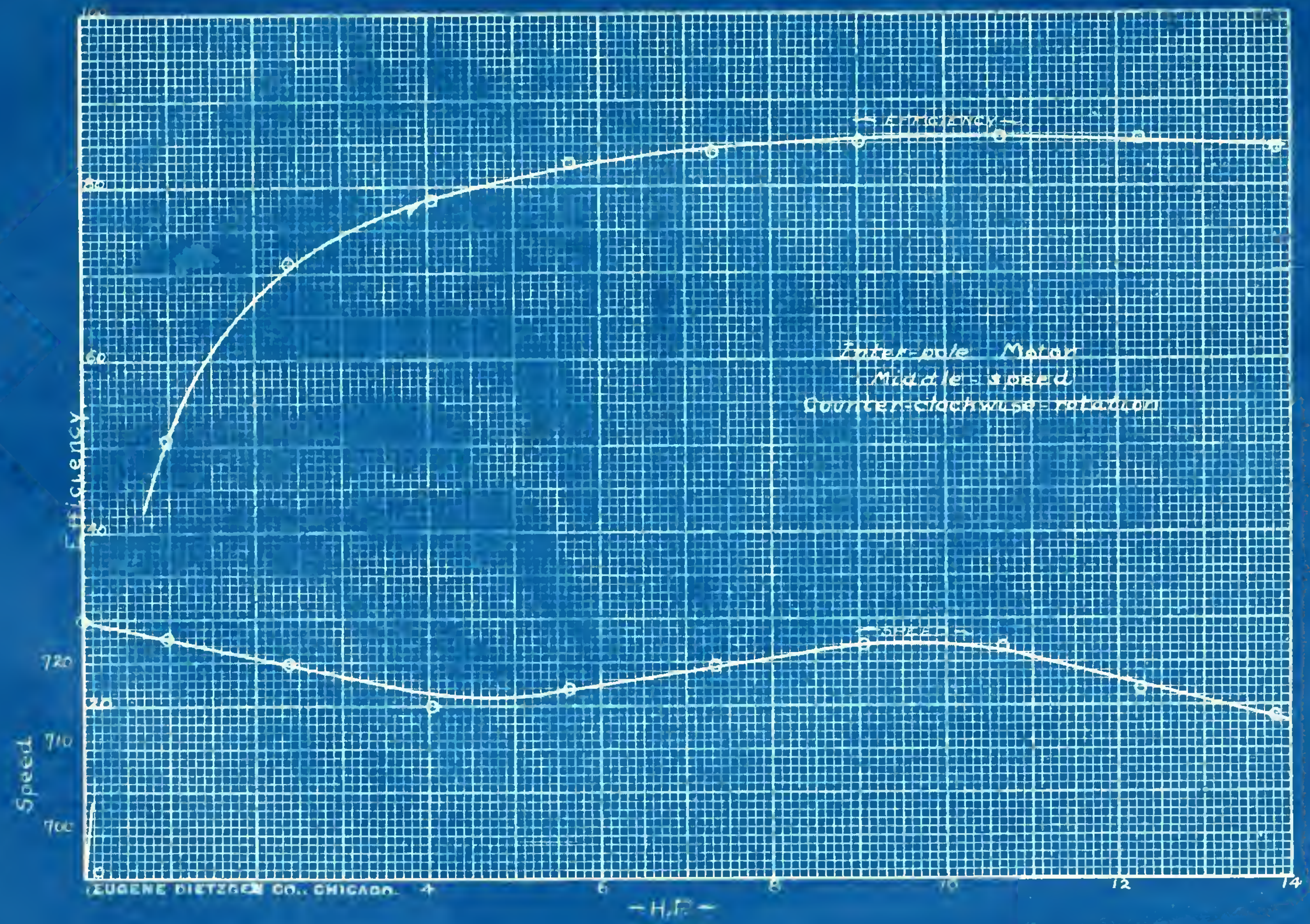
Ia.	If.	Watt Input	Speed	Wt.	H. P	Eff.
3.6	1.31	540	725	0	0	0
11.8	1.31	1441	723	3.56	.98	50.8
21.6	1.315	2520	715	8.8	2.4	71.
33.6	1.315	3840	715	14.8	4.03	78.4
45.4	1.315	5138	717	20.8	5.67	82.4
53.1	1.3	6534	720	26.8	7.35	84.0
70.6	1.295	7908	722	32.8	9.01	85.
83.1	1.295	9284	722	38.8	10.63	85.9
96.1	1.3	10714	717	44.8	12.27	85.4
11.05	1.295	12298	714	50.8	13.84	84.1
12.18	1.295	13541	708	56.8	15.34	84.6
135.0	1.295	14993	703	62.8	16.8	83.7

E---110 Volts

5.	1.295	465	725	0	0	0
10.7	1.295	1519	717	2.98	.314	41.1
23.6	1.295	2739	711	9.98	2.7	73.75
33.2	1.29	3795	708	14.8	3.99	78.5
44.4	1.29	5026	709	20.8	5.63	83.5
56.5	1.29	6357	708	26.8	7.23	84.9
69.5	1.29	7787	711	32.8	8.89	85.2
829	1.29	9261	713	38.8	10.54	84.9
97.5	1.295	10868	717	44.8	12.27	84.3
110.7	1.29	12520	722	50.8	13.99	85.3
124.7	1.29	13955	717	56.8	15.62	83.5
133.	1.285	[illegible]	713	[illegible]	17.[illegible]	[illegible]



Inter-pole Motor
Middle-speed
Counter-clockwise-rotation
EFFICIENCY
SPEED
Efficiency
Speed
100
80
60
40
720
710
700
4
6
8
10
12
14
-H.P.-
EUGENE DIETZGEN CO., CHICAGO.

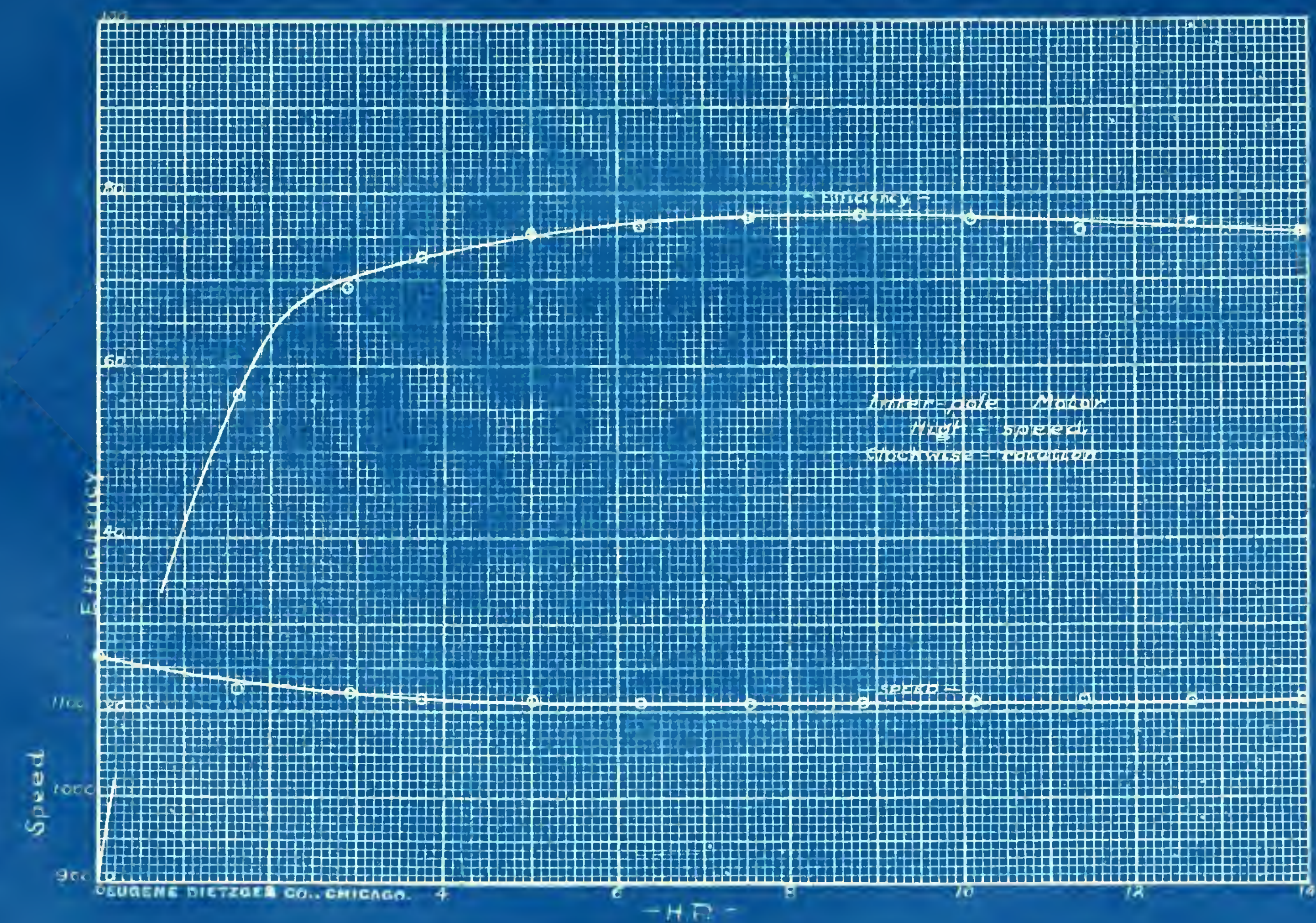

Inter-pole Motor
Middle speed
Counter-clockwise rotation
← EFFICIENCY →
← SPEED →
Efficiency
Speed
720
710
700
4
6
8
10
12
14
— H.P. —
EUGENE DIETZGEN CO., CHICAGO.

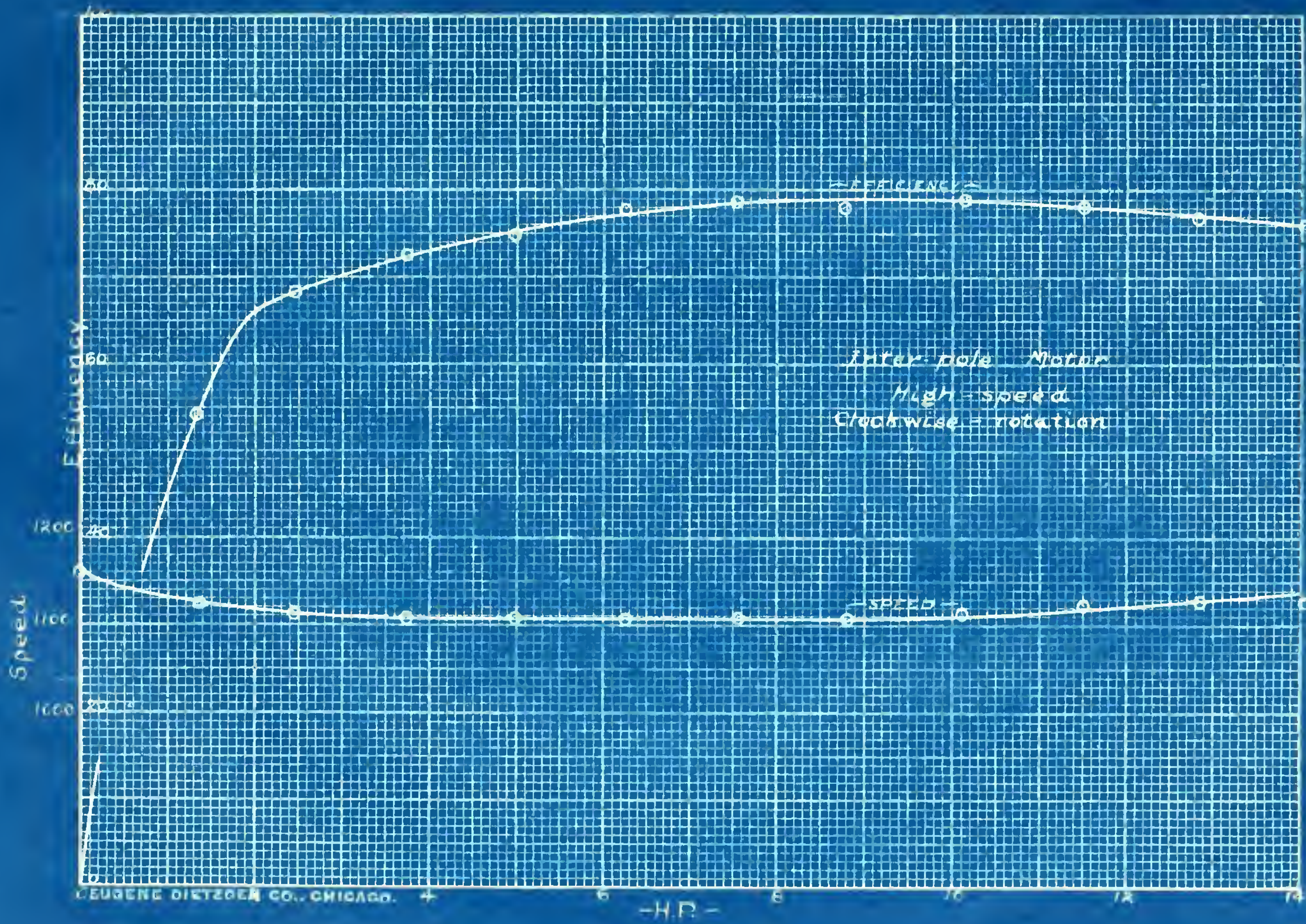
Interpole Motor.

Ia.	High Speed If.	Watt Input	Clockwise Rotation. Speed	Wt.	H.P.	Eff.
5,3	.83	455	1160	0.	0.	0.
13.1	.83	1365	1125	3.16	1.35	54.5
23.7	.83	2398	1117	5.68	2.47	35.4
34.1	.83	3842	1110	8.8	3.72	72.5
44.4	.83	4975	1110	11.8	4.99	74.2
54.2	.83	6053	1109	14.8	6.25	77.[illegible]
64.0	.83	7151	110[illegible]	17.3	7.5[illegible]	78.4
76.0	.83	8471	1102	20.8	8.[illegible]	77.[illegible]
86.3	.83	9584	1117	23.2	10.1	7[illegible]
99.0	.83	10981	1125	26.8	11.5	7[illegible]
112.	.83	12411	1120	29.3	12.[illegible]	77.[illegible]
124.9	.83	13930	1125	32.8	14.07	76.
135.5	.83	14996	1113	35.6	15.17	77.5

3.4	.835	435	1130	0.	0.	0.
18.6	.835	2137	1105	3.89	1.63	56.5
27.7	.835	3138	1122	6308	2.0	62.[illegible]
34.1	.835	3342	1115	8.8	3.74	77.7
44.4	.835	4975	1113	11.8	5.02	77.4
54.8	.835	6119	1110	14.8	6.26	77.4
65.6	.835	7307	1110	17.3	7.55	77.[illegible]
77.3	.835	8484	1110	20.8	8.31	77.50
88.2	.835	8795	1113	23.2	10.1	77.[illegible]
101.5	.835	11256	1117	26.3	11.59	77.7
110.	.835	12301	1113	29.3	12.36	77.[illegible]
124.3	.835	13919	1113	32.8	13.92	77.1
136.0	.835	14451	1100	35.3	15.0	77.5

E---110 Volts.


Inter-pole Motor
High speed
Clockwise rotation
Efficiency
Speed
Efficiency
Speed
100
80
60
40
20
1100
1000
900
4
6
8
10
12
14
H.P.
EUGENE DIETZGEN CO., CHICAGO.


Inter-pole Motor
High-speed
Clockwise-rotation
-EFFICIENCY-
-SPEED-
Efficiency
Speed
80
60
40
20
1200
1100
1000
4
6
8
10
12
14
-H.P.-
EUGENE DIETZGEN CO., CHICAGO.

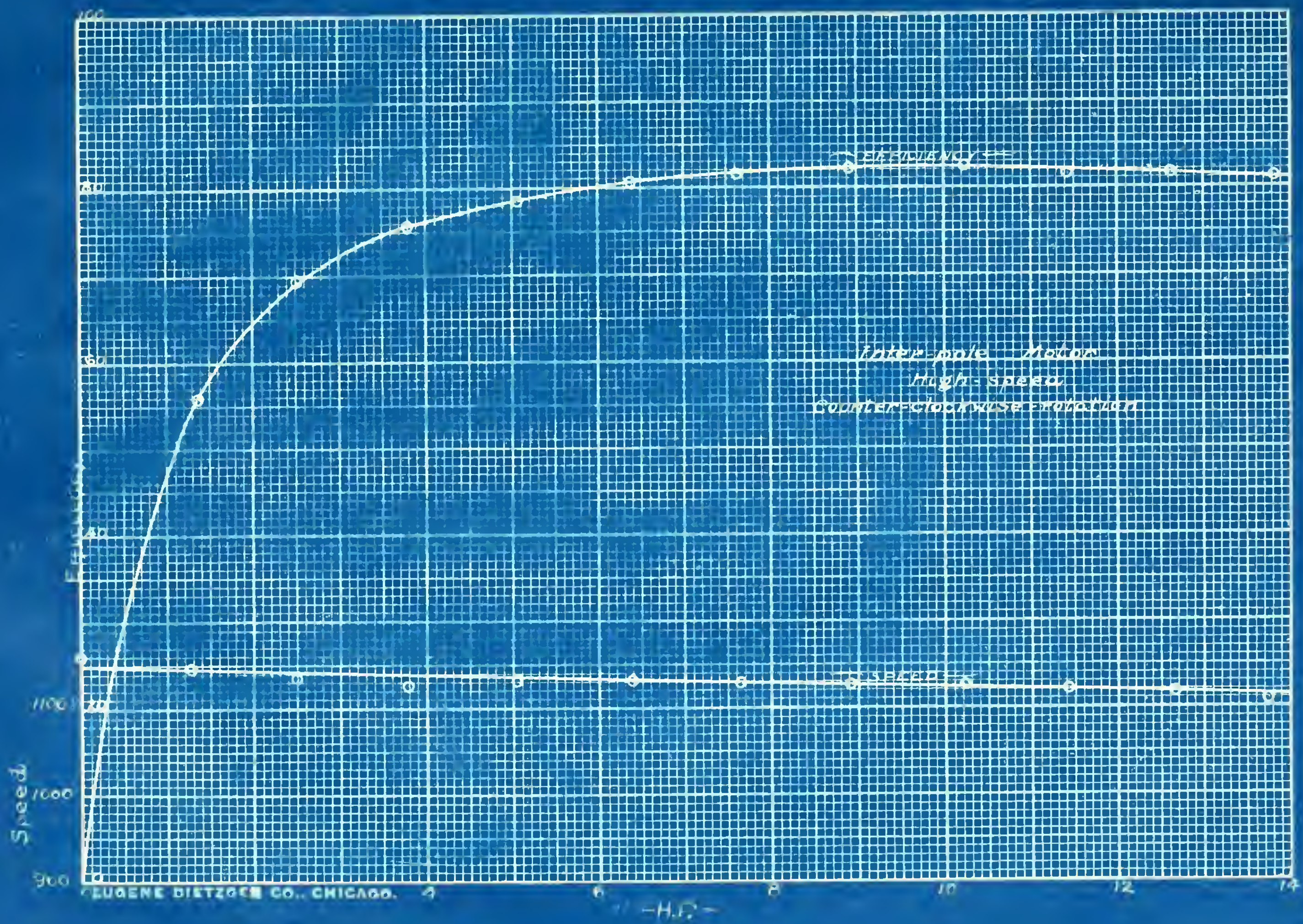
Interpole Motor

High Speed Counter Clockwise Rotation.

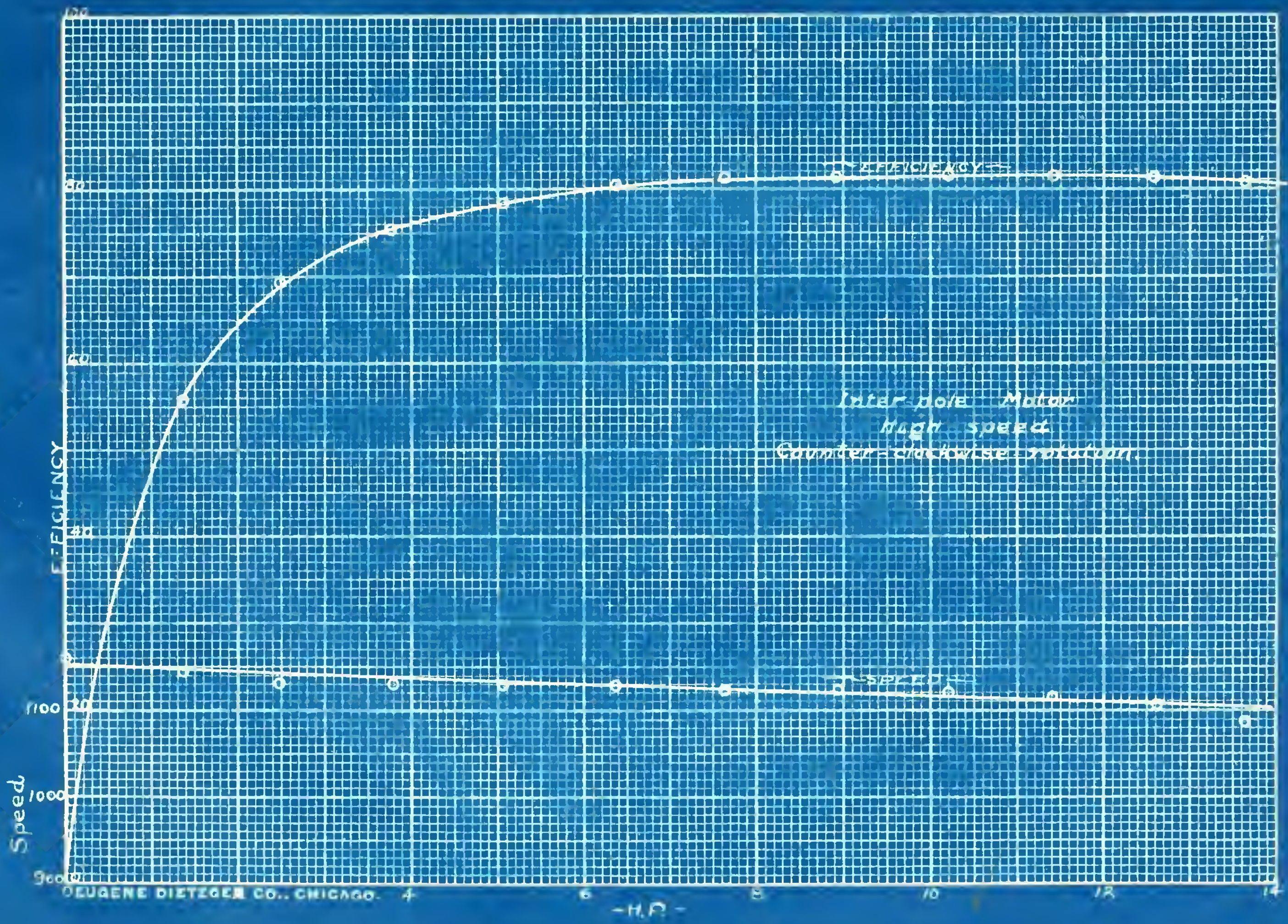
Ia.	If.	Watt Input	Speed	Wt.	H. P.	Eff.
3.2	.805	440	1130	0	0	0
15.7	.805	1815	1142	3.2	1.39	57.3
23.6	.805	2684	1130	5.8	2.49	69.5
33.4	.805	3762	1130	8.8	3.79	75.2
43.0	.905	4818	1128	11.8	5.08	78.7
53.	.805	5918	1128	14.8	6.37	80.4
63.1	.805	7039	1124	17.8	7.64	81.1
73.5	.805	8173	1124	20.8	8.92	81.4
84.3	.805	9361	1124	23.8	10.21	81.5
94.2	.805	10461	1117	26.8	11.41	81.5
104.2	.805	11551	1107	29.8	12.58	81.2
113.4	.805	12562	1089	32.8	13.62	80.9
122.3	.905	13541	1076	35.8	14.70	81.0
132.7	.805	14635	1056	38.8	15.63	79.5

3.2	.8	440	1130	0.	0.	0.
16.1	.8	1859	1148	3.16	1.38	56.
23.6	.8	2684	1133	5.8	2.50	69.6
33.2	.8	3740	1128	8.8	3.78	75.5
43.0	.8	4818	1130	11.8	5.08	78.9
53.1	.8	5929	1130	14.8	6.38	80.3
62.7	.79	6984	1136	17.8	7.64	81.6
72.9	.79	8106	1129	20.8	8.95	82.4
83.8	.79	9305	1126	23.8	10.22	82.1
94.3	.79	10449	1120	26.8	11.42	81.6
104.5	.79	11582	1116	29.8	12.68	81.8
115.0	.79	12737	1104	32.8	13.82	81.0
125.3	.79	13870	1091	35.9	14.9	80.2
134.7	.79	14904	1075	38.8	15.89	79.6

E----110 Volts.



Inter-pole Motor
High-Speed
Counter-clockwise rotation
EFFICIENCY
SPEED
Efficiency
Speed
100
80
60
40
20
1100
1000
900
4
6
8
10
12
14
-H.P.-
EUGENE DIETZGEN CO., CHICAGO.


Inter-pole Motor
High speed
Counter-clockwise rotation.
EFFICIENCY
SPEED
EFFICIENCY
Speed
100
80
60
40
20
1100
1000
900
4
6
8
10
12
14
-H.P.-
EUGENE DIETZGEN CO., CHICAGO.

Interpole Motor.

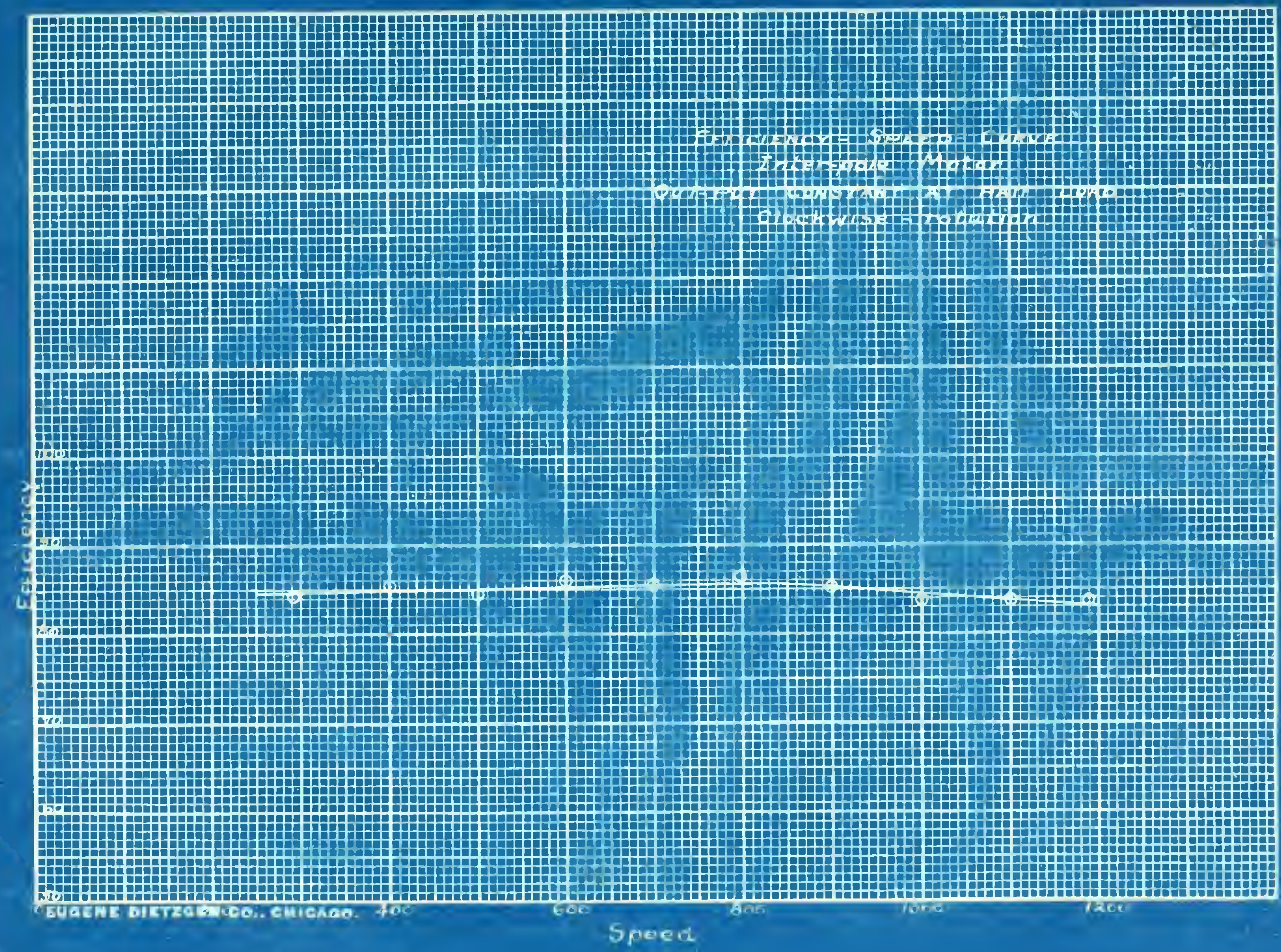
Half Load (Constant) Counter Clockwise Rotation.

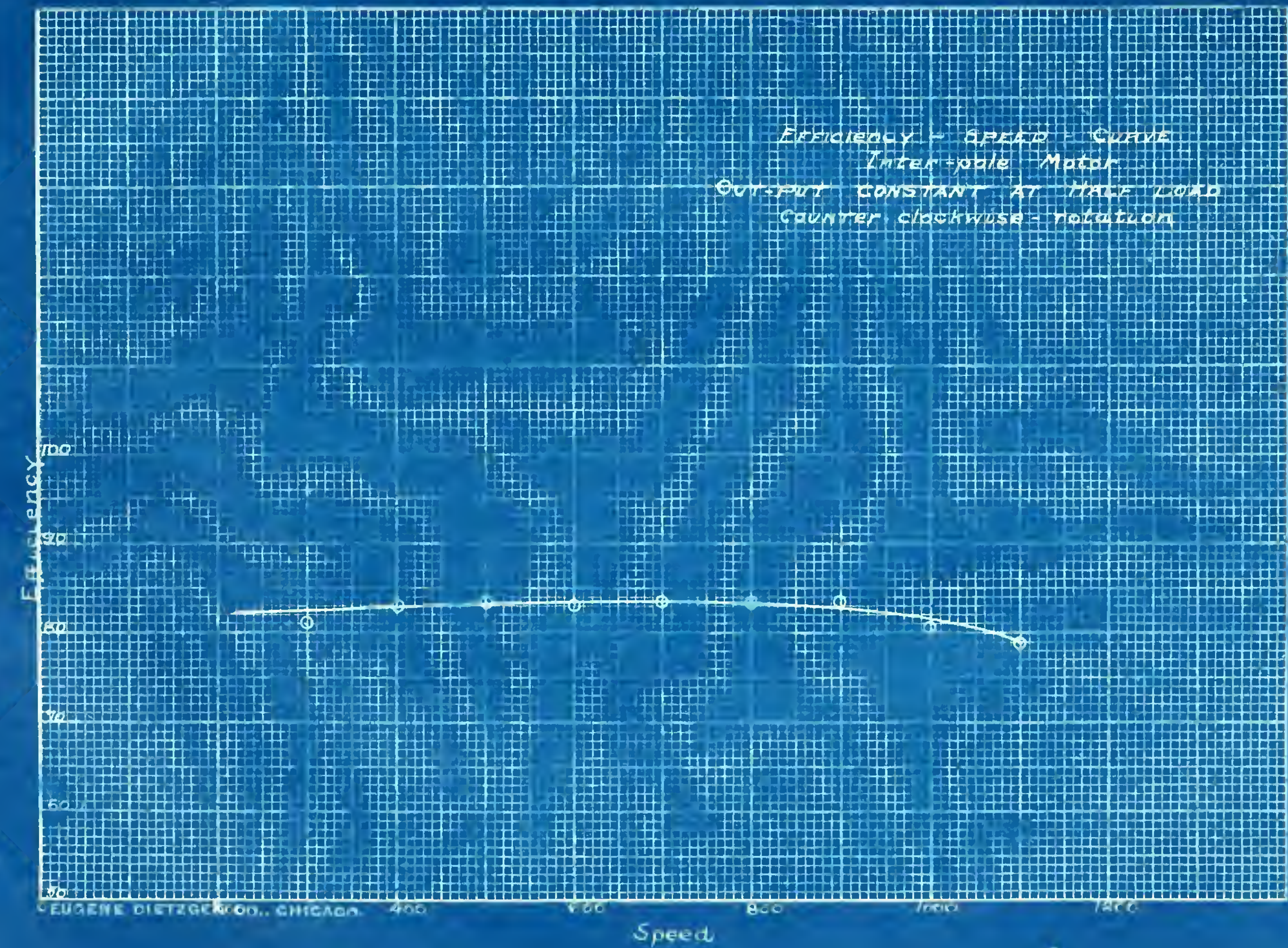
Ia	If.	Watt Input.	Speed.	Wt.	H. P.	Eff.
59.8	4.04	7022	[illegible]	67.9	7.62	[illegible]
59.0	2.35	6748	400	49.2	7.5	[illegible]
59.1	1.79	6695	500	39.36	7.5	[illegible]
59.8	1.55	6748	600	32.8	7.5	[illegible]
59.8	1.27	6717	700	28.14	7.5	[illegible]
59.8	1.13	6702	800	24.6	7.5	[illegible]
60.	1.01	6711	900	21.86	7.5	[illegible]
60.1	.94	6714	1000	19.69	7.5	[illegible]
62.5	.83	6366	1100	17.9	7.5	[illegible]
63.6	.77	7080	[illegible]	16.95	7.5	79.

Half Load (Constant) Clockwise Rotation.

Ia	If.	Watt Input.	Speed.	Wt.	H. P.	Eff.
59.1	4.05	[illegible]	303	67.9	7.34	84.4
57.0	2.41	6555	400	49.2	7.5	[illegible]
58.4	1.82	6622	500	39.36	7.5	84.5
57.7	1.5	6512	600	32.8	7.5	[illegible]
58.0	1.38	6520	700	28.14	7.5	85.5
57.7	1.13	6471	800	24.6	7.5	86.5
58.7	1.02	6569	900	21.86	7.5	[illegible]
59.8	.93	6680	1000	19.69	7.5	[illegible]
59.8	.84	6670	1100	17.9	7.5	[illegible]
60.0	.8	6638	[illegible]	16.95	7.5	[illegible]

E-- 110 Volts.


Efficiency - Speed Curve
Interpole Motor
Output Constant at Half Load
Clockwise Rotation
Efficiency
Speed
400
600
800
1000
1200
EUGENE DIETZGEN CO., CHICAGO.


Efficiency - Speed - Curve
Inter-pole Motor
Out-put Constant at Half Load
Counter clockwise - rotation
Efficiency
100
90
80
70
60
50
Speed
400
600
800
1000
1200
EUGENE DIETZGEN CO., CHICAGO.

Interpole Motor

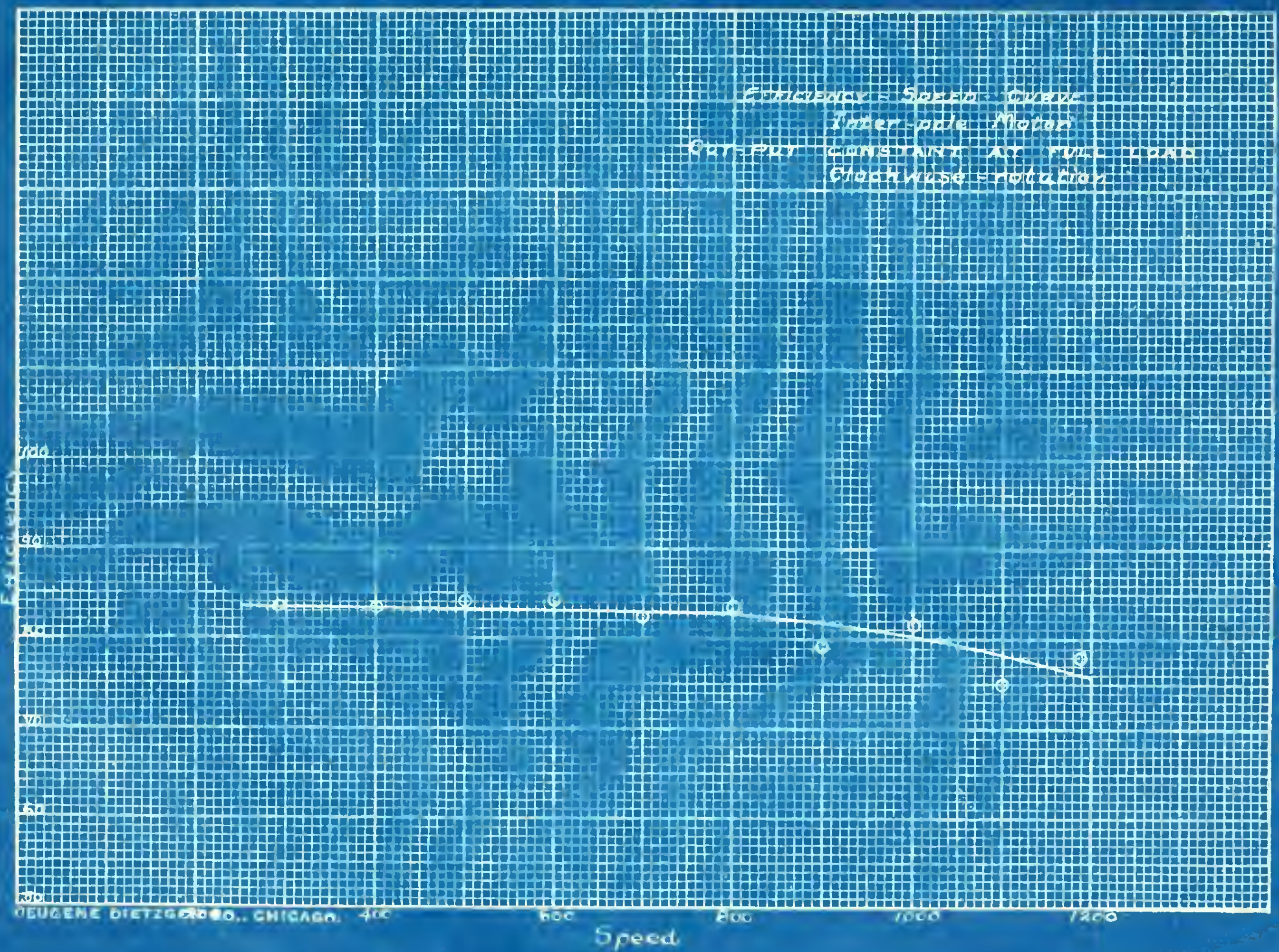
Full Load (Constant) Clockwise Rotation.

Ia	If	Watt Imput	Speed	W. T	H. P.	Eff.
121.8	3.9	13827	292	135.6	15	81.5
120	2.49	13474	400	98.5		8.32
119	1.9	13299	500	78.76		84.95
119	1.57	13256	600	65.66		84.5
131.8	1.35	13546	700	56.26		82.6
120.8	1.20	13440	800	49.26		83.3
127.8	1.03	14171	900	43.74		79.1
123.6	.94	13669	1000	39.39		81.9
127.1	.85	14916	1100	35.74		75.
129.5	.8	14333	1190	33.08		78.

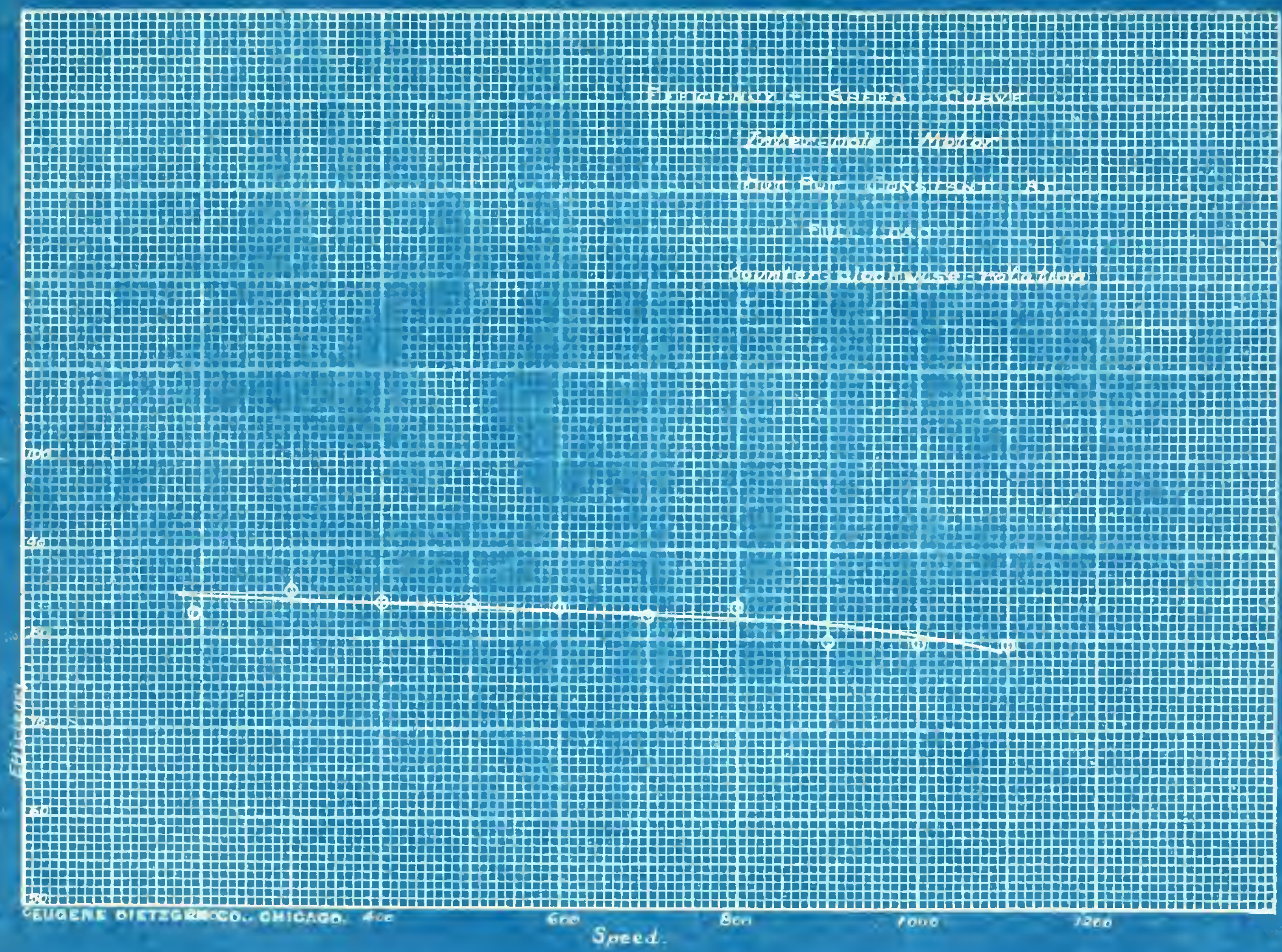
Full Load (Constant) C. C. Rotation.

119.	3.06	13525	292	135.6	15	82.3
117.	2.45	13139	400	98.5		85.2
119	1.88	13296	500	78.76		84.25
120	1.5	14701	600	65.66		76.2
120.8	1.3	13431	700	56.26		83.3
122.3	1.13	13577	800	49.26		82.5
120.8	1.0	13398	900	43.74		83.6
126.8	.87	14043	1000	39.33		79.8
127.	.8	14058	1100	35.74		79.75
127.8	.74	14159	1190	33.08		79.2

110 Volts



Efficiency - Speed Curve
Inter-pole Motor
Out-put Constant at Full Load
Clockwise - Rotation
Efficiency
100
90
80
70
60
50
400
600
800
1000
1200
Speed
EUGENE DIETZGEN CO., CHICAGO.



Efficiency - Speed Curve
Interpole Motor
Full Load
Counter-clockwise rotation
100
90
80
70
60
50
400
600
800
1000
1200
Speed.
Efficiency
EUGENE DIETZGEN CO., CHICAGO.

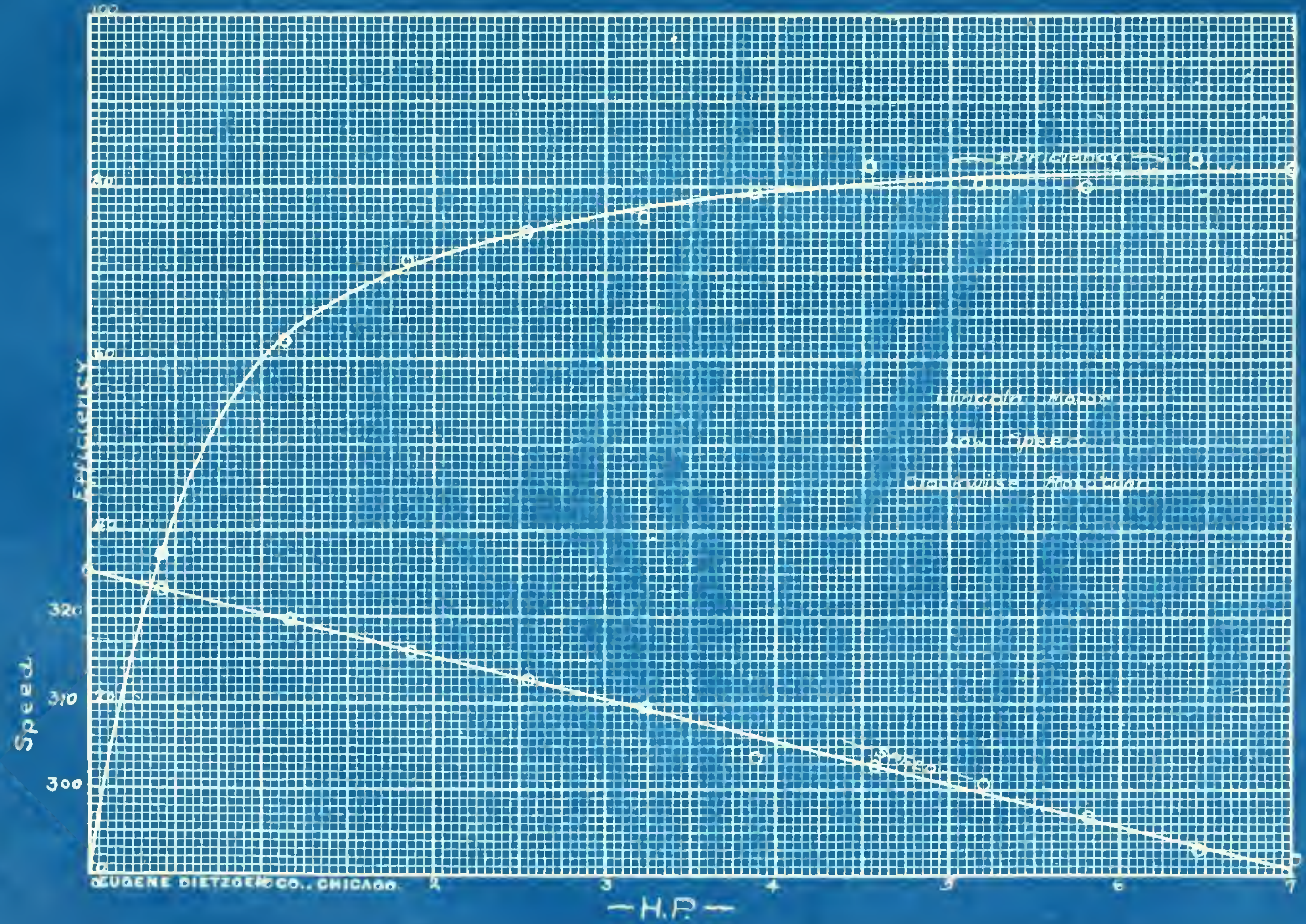
Lincoln Motor

Low Speed Clockwise Rotation.

Ia.	If.	Watt Input	Speed	Wt.	H.P.	Eff.
2.5	2.32	558	325	0.	0.	0.
5.3	2.36	547	322	3.5	.490	[illegible]
10.3	2.35	1321	320	9.5	1.16	62.
15.7	2.35	1985	316	15.5	1.87	70.4
21.4	2.35	2312	312	21.5	2.53	71.2
26.4	2.35	3132	308	27.5	3.24	73.4
30.[illegible]	2.35	3343	305	33.5	[illegible]	[illegible]
36.4	2.35	4262	303	39.5	4.[illegible]	[illegible]
44.4	2.35	4912	301	45.5	5.21	[illegible]
46.7	2.32	5392	295	51.5	5.75	[illegible]
48.8	2.32	5623	295	57.5	6.42	[illegible]
55.0	2.32	[illegible]	293	63.5	7.10	[illegible]
61.0	2.32	6965	[illegible]	69.5	7.77	[illegible]

5.5	2.35	365	325	3.5	.036	7.7
10.5	2.35	1423	320	9.5	1.17	[illegible]
15.6	2.32	1917	316	15.5	[illegible]	[illegible]
20.7	2.32	2532	314	21.5	2.50	73.4
26.5	2.32	3170	312	27.5	3.25	76.5
31.2	2.32	3687	304	33.5	[illegible]	[illegible]
36.1	2.32	[illegible]	303	39.5	[illegible]	[illegible]
41.9	2.31	4862	301	45.5	5.22	[illegible]
47.6	2.31	5490	301	51.5	5.91	[illegible]
51.6	2.30	[illegible]	293	57.5	6.51	[illegible]
57.5	2.30	6579	293	63.5	7.03	[illegible]
62.1	2.29	7083	291	69.5	7.72	[illegible]

E ---- 110 Volts.



Efficiency
Speed
Lincoln Motor
Low Speed
Clockwise Rotation
100
90
320
310
300
2
3
4
5
6
7
—H.P.—
EUGENE DIETZGEN CO., CHICAGO

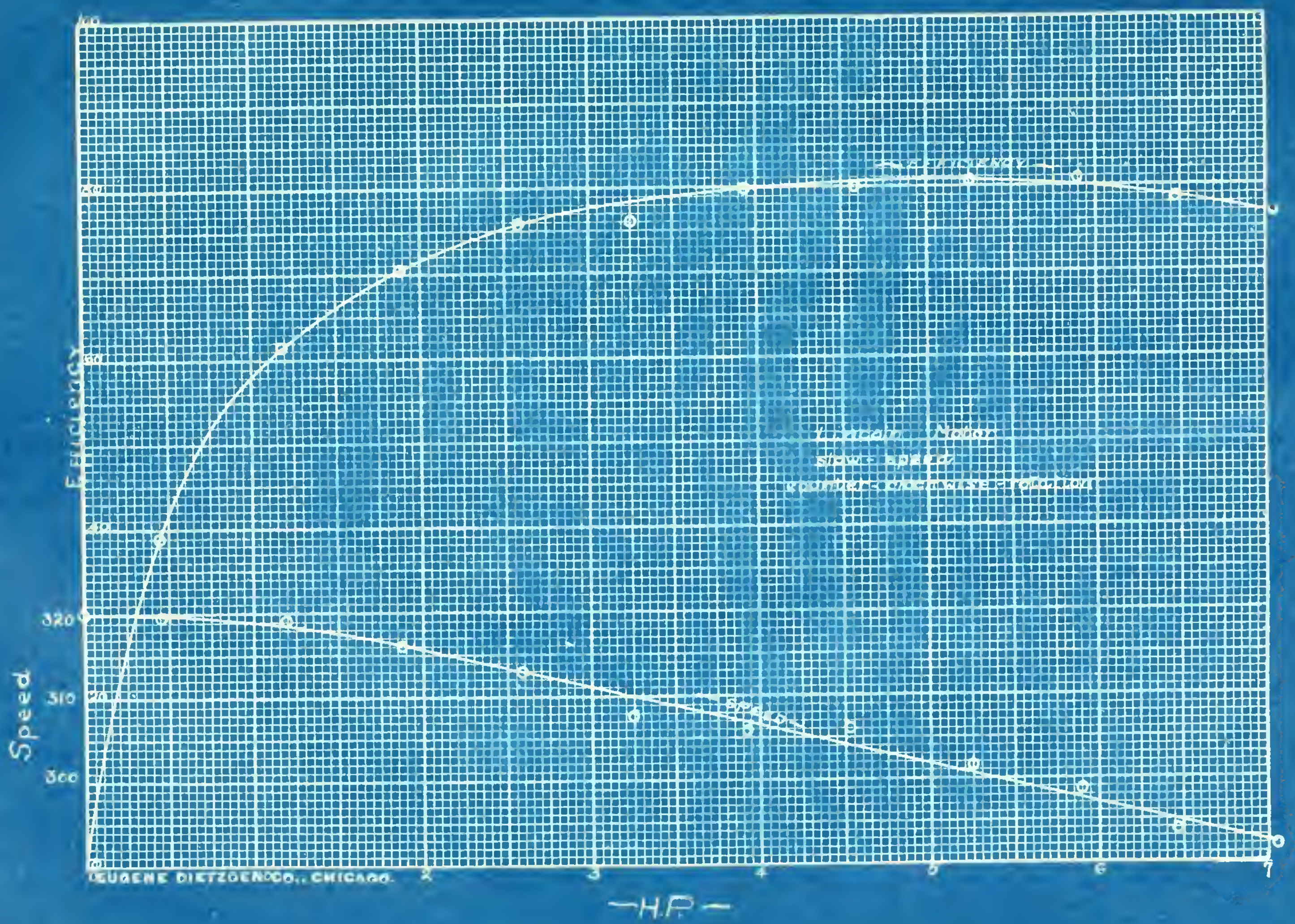
Line In[illegible].

Low Speed Counter Clockwise Rotation.

Ia.	If.	Watts Input	Speed.	t.	H. P.	Eff.
3.6	2.5	371	[illegible]	0.	0.	[illegible]
5.5	2.43	373	31[illegible]	3.7	.45	[illegible]
10.75	2.43	1440	[illegible]	[illegible].7	1.[illegible]	[illegible]
15.6	2.42	1[illegible]2	316	15.7	1.[illegible]	7[illegible]
20.9	2.42	25.65	312	21.7	2.6	[illegible]
26.3	2.42	3159	306	27.7	3.[illegible]	[illegible]
31.0	2.42	3576	304	33.7	3.9	[illegible]
33.5	2.42	4[illegible]1	302	39.7	4.5[illegible]	[illegible]
41.5	2.42	[illegible]1	301	45.1	[illegible]	[illegible]
46.0	2.41	[illegible]	[illegible]	51.7	[illegible]	[illegible]
54.2	2.41	[illegible]7	293	57.7	6.44	[illegible]
61.8	2.40	7067	[illegible]	63.7	7.06	[illegible]

5.5	2.4	369	[illegible]	3.7	.450	[illegible].7
10.5	2.39	1417	319	9.7	1.19	[illegible]
15.6	2.38	1977	316	15.7	1.87	70.[illegible]
20.7	2.38	2538	314	21.7	2.[illegible]	73.[illegible]
26.7	2.37	3127	310	27.7	[illegible]	76.4
31.2	2.37	3602	308	[illegible].7	[illegible]3	[illegible]
37.0	2.37	4330	303	39.7	4.35	[illegible]
41.9	2.36	4838	300	45.7	[illegible]	[illegible].7
47.0	2.36	5530	299	51.7	5.89	[illegible].4
53.0	2.35	6088	295	57.7	6.40	[illegible]
59.0	2.35	6748	293	63.7	7.11	75.7

E=110 Volts.



Efficiency
Speed
320
310
300
2
3
4
5
6
7
—H.P.—
EUGENE DIETZGEN CO., CHICAGO.

Lincoln Motor.

Middle Speed [illegible]

Ia.	If.	Speed.	[illegible]t.	Watt Input.	H.P.	Eff.
2.	2.31	[illegible]	[illegible]	474	[illegible]	[illegible]
8.3	2.31	[illegible]	1.7	1137	[illegible]	[illegible]
15.6	2.309	[illegible]	4.5	[illegible]	[illegible]	[illegible]
22.0	2.307	[illegible]	7.[illegible]	[illegible]	[illegible]	[illegible]
28.	2.307	[illegible]	9.5	3353	[illegible]	[illegible]
35.4	2.307	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
43.0	2.307	903	14.5	4933	[illegible]	[illegible]
49.5	2.28	884	17.0	5375	5.72	[illegible]
56.0	2.279	875	19.5	6410	6.5	[illegible]
62.3	2.27	865	22.0	7102	7.25	76.
8.4	2.31	963	1.7	1173	[illegible]	[illegible]
16.3	2.3	944	4.5	2043	[illegible]	[illegible]
21.4	2.3	953	7.0	2307	[illegible]	[illegible]
28.3	2.3	920	9.5	3500	3.35	[illegible]
34.5	2.3	910	12.0	4048	4.15	[illegible]
43.0	2.28	900	14.5	4930	[illegible]	74.4
49.3	2.279	987	17.0	5373	5.75	[illegible]
55.3	2.279	884	19.5	6033	[illegible]	77.2
62.5	2.27	865	22.0	7104	7.25	[illegible]

E---110 Volts.

FORM

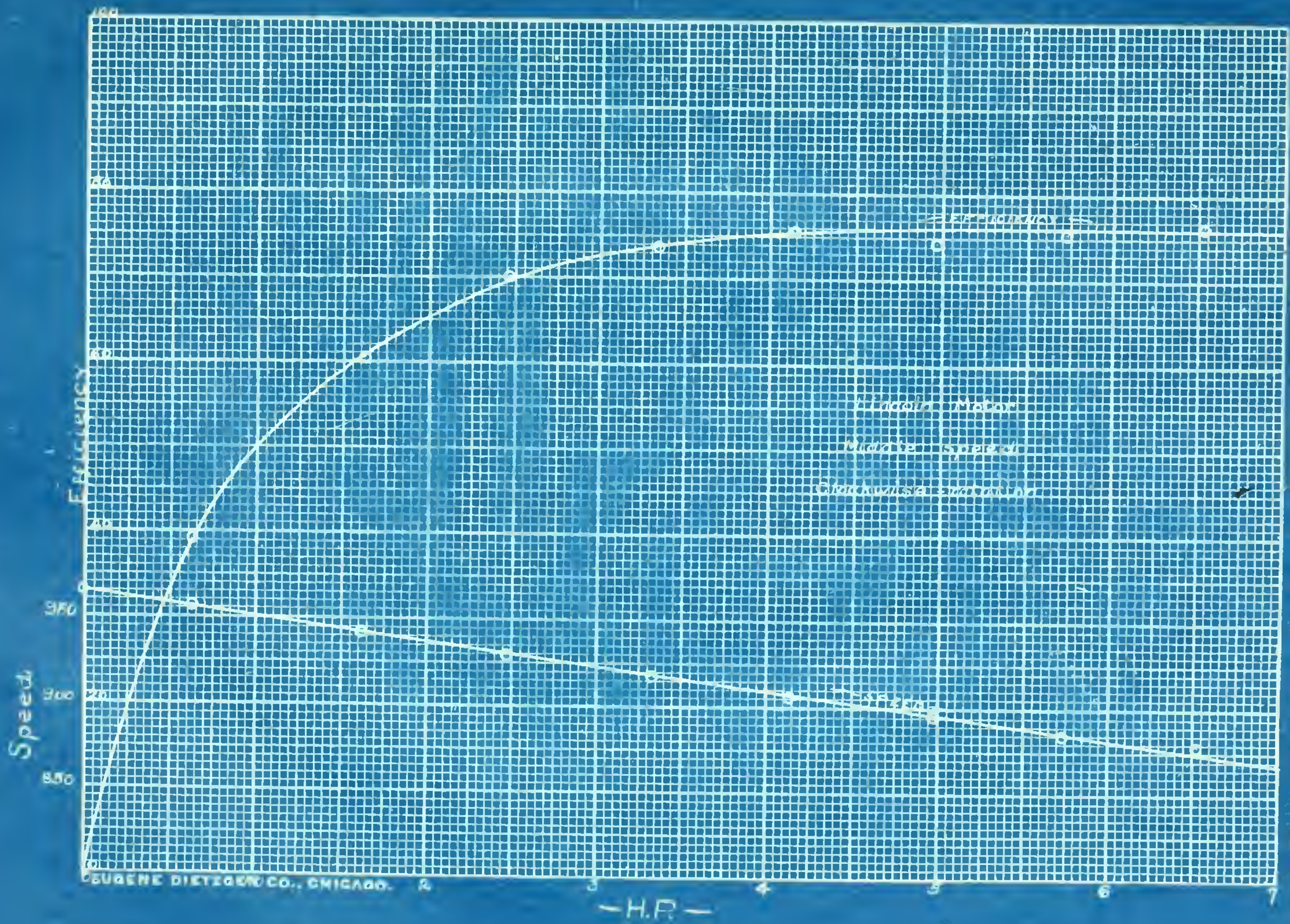
BARNES-CROSBY COMPANY

CHICAGO

GENTLEMEN:

RESPONDING TO YOURS OF

CONC


Lincoln Motor
Middle Speed
Clockwise rotation
Efficiency
Speed
Efficiency
Speed
—H.P.—
EUGENE DIETZGEN CO., CHICAGO.

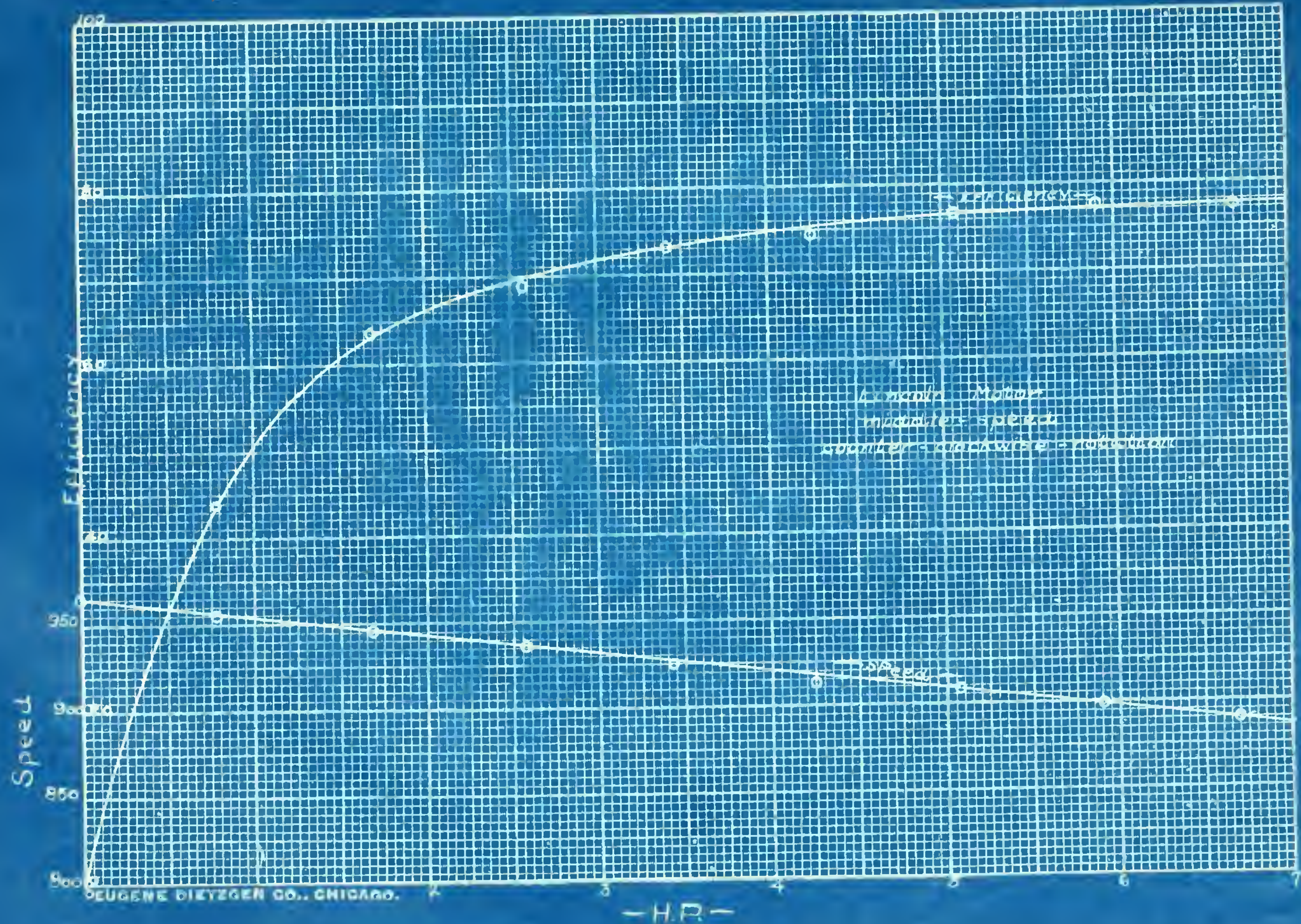
Lincoln Motor

Middle Speed Counter Clockwise Rotation.

Ia	If	Watt Imput	Speed	Weight	H.P.	Eff.
2.05	2.41	490	963	0	0	0
9.9	2.40	1353	953	2.2	.8	44.2
15.6	2.405	1980	945	4.7	1.60	63.0
22.9	2.40	2783	934	7.2	2.56	68.6
29.6	2.39	3519	923	9.7	3.41	72.4
36.5	2.37	42.75	911	12.2	4.24	74.0
42.0	2.38	4991	904	14.7	5.06	75.7
49.2	2.37	5672	900	17.2	5.9	77.6
56.7	2.37	6497	892	19.7	6.7	77.0
63.6	2.37	7256	881	22.2	7.45	76.5

9.5	2.4	1309	955	2.1	.765	43.6
15.6	2.38	1977	945	1.7	1.60	63.0
22.9	2.37	1779	936	7.2	2.57	6 9.00
29.1	2.37	3461	926	9.7	3.42	73.8
36.1	2.37	4231	915	12.2	4.25	74.9
42.3	2.37	4913	908	14.7	5.08	77.2
48.8	2.37	5628	900	17.2	5.9	78.2
56.4	2.37	6464	892	19.7	6.7	77.4
64.0	2.36	7200	881	22.2	7.45	75.2

E = 110 Volts.

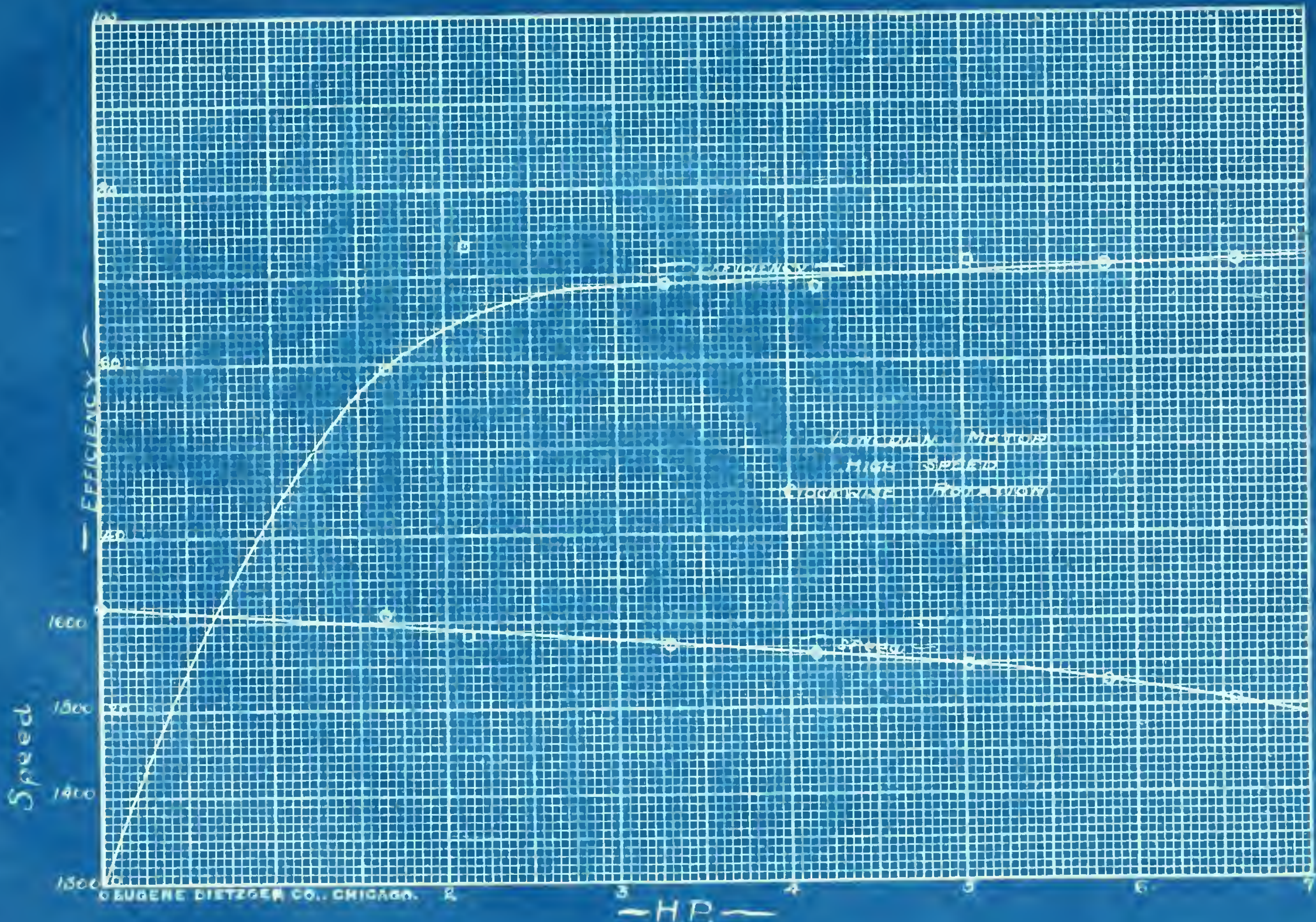

100
80
60
Efficiency
40
950
900
850
800
Speed
EUGENE DIETZGEN CO., CHICAGO.
2
3
4
5
6
7
—H.P.—
Efficiency
Speed
Lincoln Motor
middle - speed
counter - clockwise - rotation

Lincoln Motor.

High Speed, Clockwise Rotation.

Ia.	If	Watt Input	Speed	Wt,	H. P.	Eff.
3.3	2.43	3.63	1620	0	0	0
17.2	2.43	2159	1580	4.5	2.11	73.
30.6	2.42	3332	1560	5.5	3.27	67.2
40.	2.42	4666	1548	7.0	4.13	66.2
45.9	2.41	5314	1540	8.5	5.0	70.2
52.9	2.40	6035	1517	10.0	5.79	71.0
61.6	2.40	7040	1480	11.5	6.53	69.4
67.5	2.38	7686	1430	13.0	7.38	71.6
16.5	2.40	2079	1610	2.7	1.66	59.5
20.6	2.40	2570	1591	3.5	2.12	62.0.
28.1	2.40	3355	1580	5.5	3.32	73.9
37.8	2.38	4419	1572	7.0	4.2	71.0
44.8	2.38	5180	1560	8.5	5.06	72.9
54.0	2.38	6201	1538	10.0	5.86	70.6
59.7	2.37	6817	1519	11.5	6.66	72.3
69.6	2.36	7915	1511	13.0	7.49	70.6

E--110 Volts.



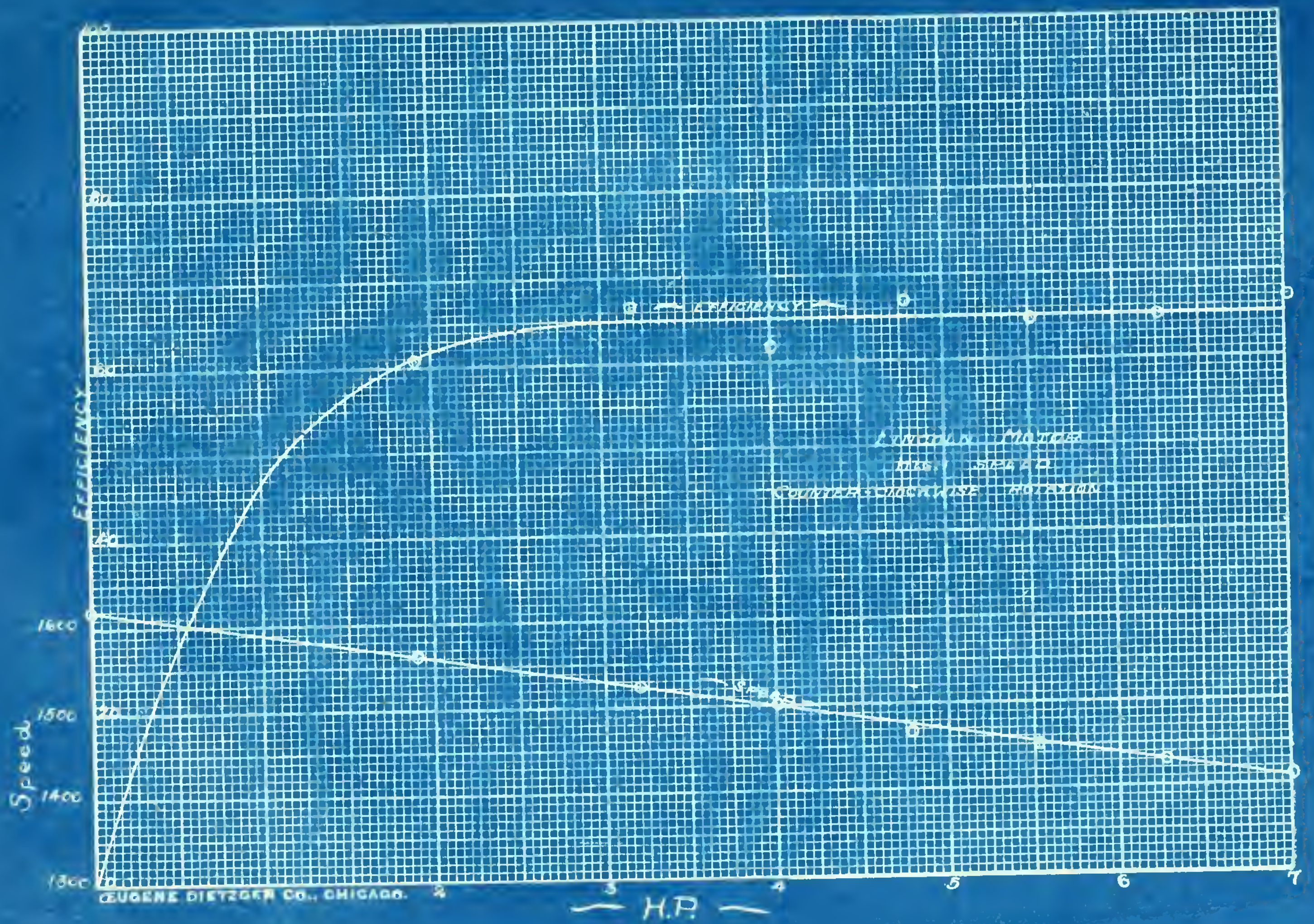
LINCOLN MOTOR
HIGH SPEED
CLOCKWISE ROTATION
EFFICIENCY
SPEED
— EFFICIENCY —
Speed
1600
1500
1400
1300
100
80
60
40
20
0
2
3
4
5
6
7
— H.P. —
EUGENE DIETZGEN CO., CHICAGO.

Lincoln Motor

High Speed Counter Clockwise Rotation,

Ia	If	Watt Input	Speed	Wt.	H P.	Eff
3.7	2.42	673	1620	0	0	0
18.0	2.40	2244	1580	3.0	1.8	60.
30.6	2.39	3623	1523	5.5	3.2	65.9
37.4	2.38	4375	1497	7.0	3.99	68.8
43.8	2.38	5079	1473	8.5	4.76	70.0
54.4	2.38	6245	1430	10.0	5.45	65.2
59.7	2.35	6935	1400	11.5	6.14	66.1
67.5	2.35	7683	1380	13.0	6.85	66.5
3.9	2.38	690	1620	0	0	0
20.2	2.35	2480	1548	3.5	2.03	61.1
30.0	2.35	3553	1520	5.5	3.19	67.0
43.0	2.35	4988	1503	7.0	4.01	60.0
48.0	2.35	5626	1489	8.5	4.32	64.0
56.7	2.35	6495	1470	10.0	5.60	64.4
65.6	2.35	7474	1462	11.5	6.41	64.0
69.6	2.35	7914	1448	13.0	7.18	67.6

E---110 Volts.



Lincoln Motor
High Speed
Counter-Clockwise Rotation
Efficiency
Speed
Efficiency
Speed
— H.P. —
1300
1400
1500
1600
20
40
60
80
2
3
4
5
6
7
EUGENE DIETZGEN CO., CHICAGO.

Lincoln Motor

Half Load (Constant)   Clockwise Rotations.

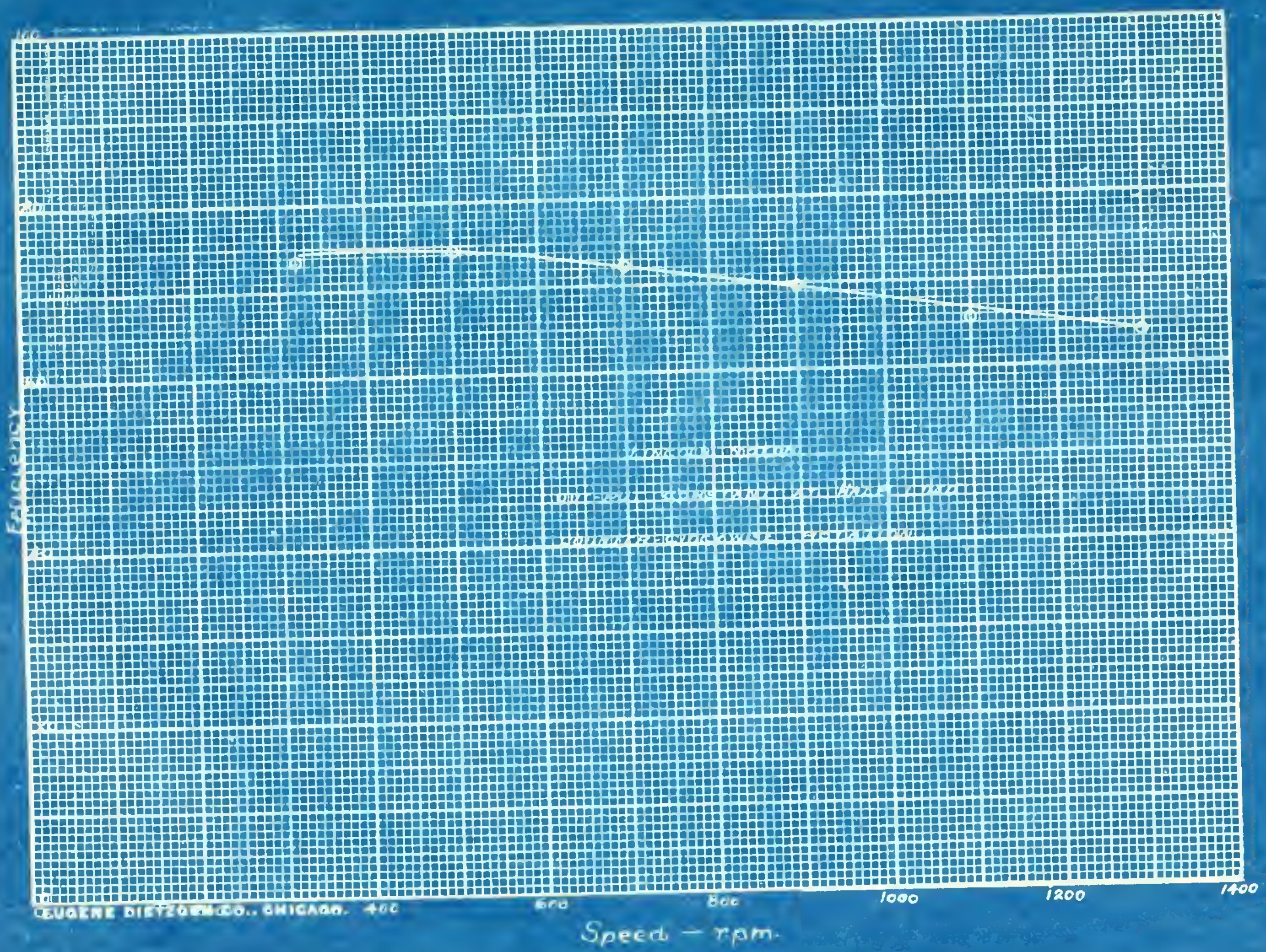
Ia	If	Watt Input	Speed	Wt.	HP.	Eff
19.9	2.4	2453	320	20.5	2.5	76.1
19.0	2.4	2354	500	13.12	2.5	79.3
20.0	2.4	2464	700	9.38	2.5	75.7
20.4	2.38	2505	900	7.3	2.5	74.5
20.9	2.39	2560	1100	5.96	2.5	73.0
21.0	2.41	2575	1300	5.65	2.5	72.5
23.2	2.41	2817	1450	4.52	2.52	66.4
22.2	2.41	2707	1620	4.05	2.52	69.0

Half Load (Constant)   Counter Clockwise Rotation

20.6	2.41	2531	320	20.5	2.5	73.3
20.4	2.41	2509	500	13.12	2.5	74.5
21.1	2.40	2585	700	9.38	2.5	72.2
22.0	2.37	2680	900	7.3	2.5	69.7
23.7	2.37	2867	1100	5.96	2.5	65.1
2.40	2.37	2900	1300	5.65	2.5	64.4
23.0	2.40	2893	1450	4.52	2.5	64.6

E=110 Volts.


Efficiency
100
80
60
40
20
0
400
600
800
1000
1200
1400
Speed — r.p.m.
EUGENE DIETZGEN CO., CHICAGO.



Efficiency
400
600
800
1000
1200
1400
Speed — r.p.m.
EUGENE DIETZGEN CO., CHICAGO.

Lincoln Motor

Full Load (Constant) Clockwise Rotation.

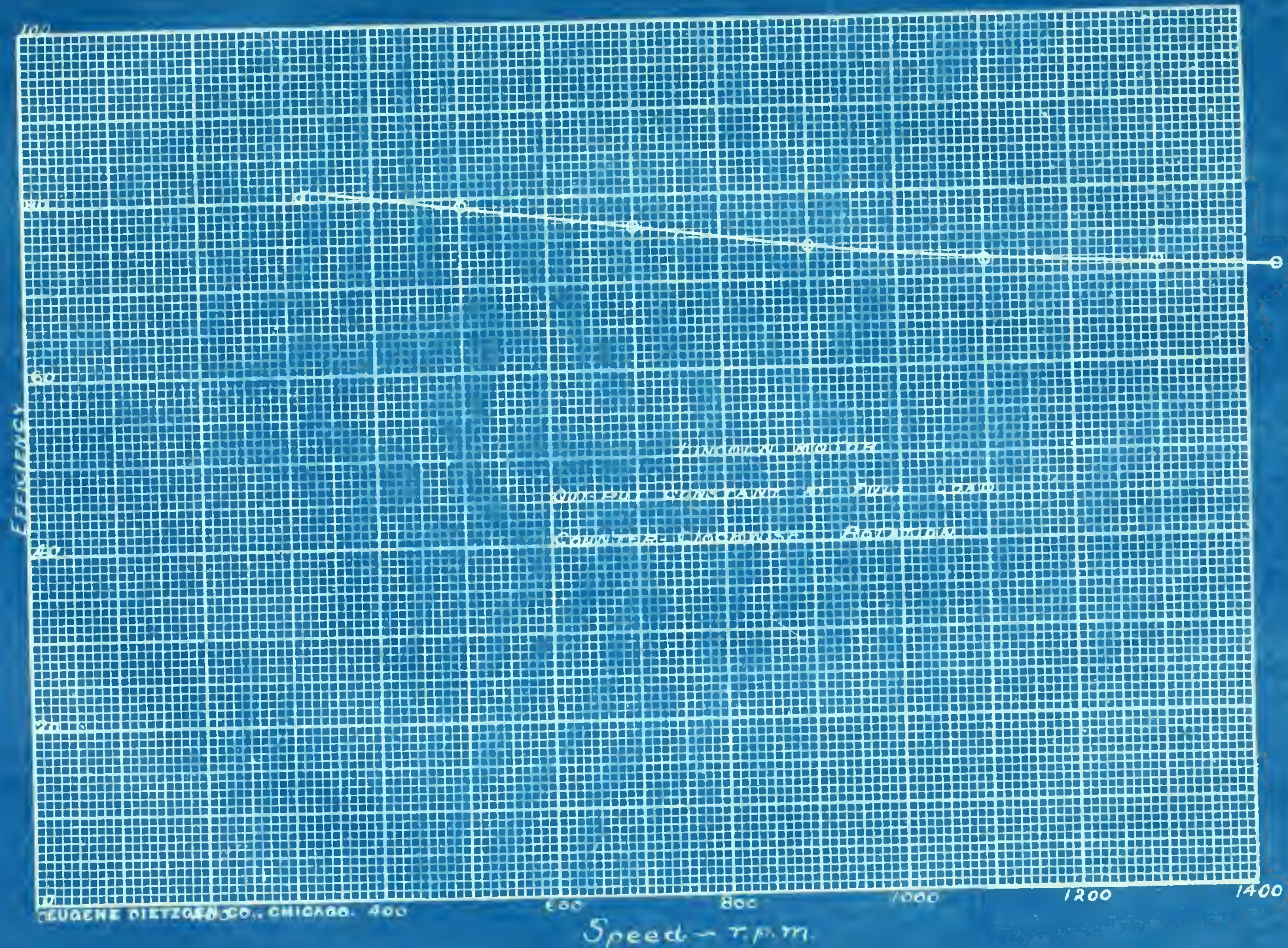
Ia	If	Watt Input	Speed	Wt.	H P	Eff.
38.2	2.39	4463	320	41.0	5.0	83.5
40.0	2.37	4660	500	26.25	5.0	81.8
36.7	2.38	4293	700	1876	5.0	86.9
41.1	2.37	4781	900	14.6	5.0	78.0
43.6	2.37	5056	1100	11.92	5.0	73.7
41.0	2.40	4774	1300	10.1	5.0	78.1
41.5	2.38	4826	1450	9.05	5.0	77.4

Full Load (Constant) Counter Clockwise Rotation.

39.6	2.42	4632	320	41.0	5.0	80.7
40.2	2.40	4686	500	2625	5.0	79.7
41.9	2.40	4873	700	1376	5.0	76.5
43.8	2.40	5082	900	14.6	5.0	73.5
44.8	2.40	5192	1100	11.92	5.0	71.9
44.8	2.40	5192	1300	10.1	5.0	71.9
45.8	2.40	5302	1450	9.05	5.0	70.4

E--110 Volts.


Lincoln Motor
Output Constant at Full Load
Clockwise Rotation
EFFICIENCY
100
80
60
40
20
0
400
600
800
1000
1200
1400
Speed - r.p.m.
EUGENE DIETZGEN CO., CHICAGO.



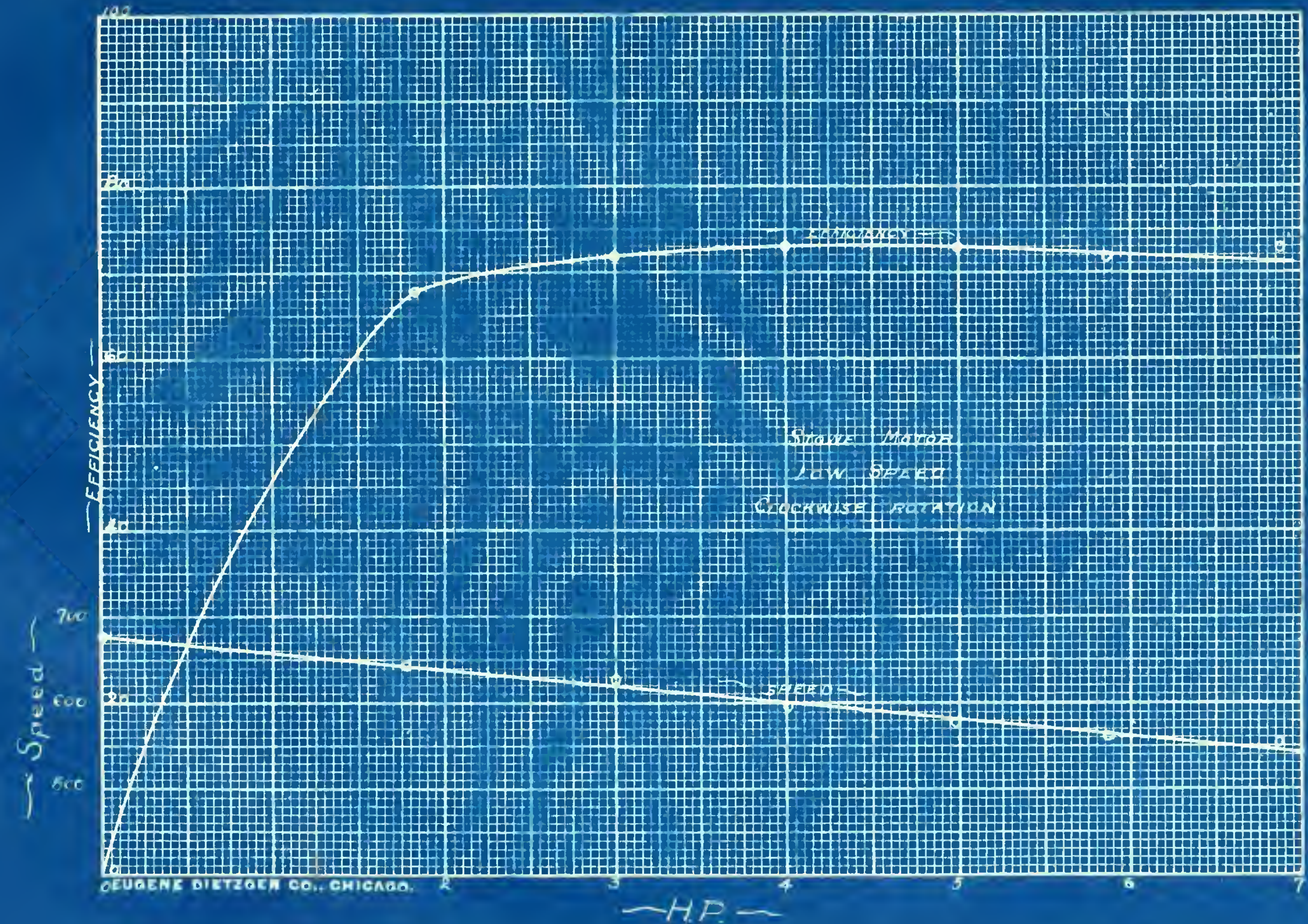
100
80
60
40
20
0
EFFICIENCY
LINCOLN MOTOR
OUTPUT CONSTANT AT FULL LOAD
COUNTER-CLOCKWISE ROTATION
400
600
800
1000
1200
1400
Speed – r.p.m.
EUGENE DIETZGEN CO., CHICAGO.

Stowe Motor

Low Speed Clockwise Rotation.

Ia.	If.	Watt Input	Speed	[illegible]t.	H. P.	Eff.
2.7	1.54	444	680	0.	0.	0.
8.7	1.53	1103	662	2.67	.67	45.[illegible]
17.4	1.53	2060	656	7.5	1.37	37.[illegible]
26.2	1.33	3028	572	12.5	3.11	7[illegible].[illegible]
34.8	1.31	3972	593	17.5	3.97	74.[illegible]
43.9	1.31	4973	577	22.5	4.91	7[illegible].7
53.5	1.31	6007	581	27.5	5.87	73.9
63.1	1.31	7085	549	32.5	6.80	7[illegible].[illegible]
72.7	1.31	8141	537	37.5	7.63	74.7
7.0	1.31	914	662	1.3	.33	2[illegible].[illegible]
16.7	1.31	1981	652	7.5	1.80	6[illegible].
27.6	1.31	3134	626	12.5	2.98	70.
37.1	1.31	4225	602	17.5	4.01	71.[illegible]
45.8	1.31	5132	585	22.5	5.01	72.[illegible]
55.3	1.31	6227	561	27.5	5.85	71.[illegible]
62.6	1.31	7030	561	32.5	6.95	7[illegible].
72.4	1.31	8108	549	37.5	7.34	71.5

E-- 110 volts.

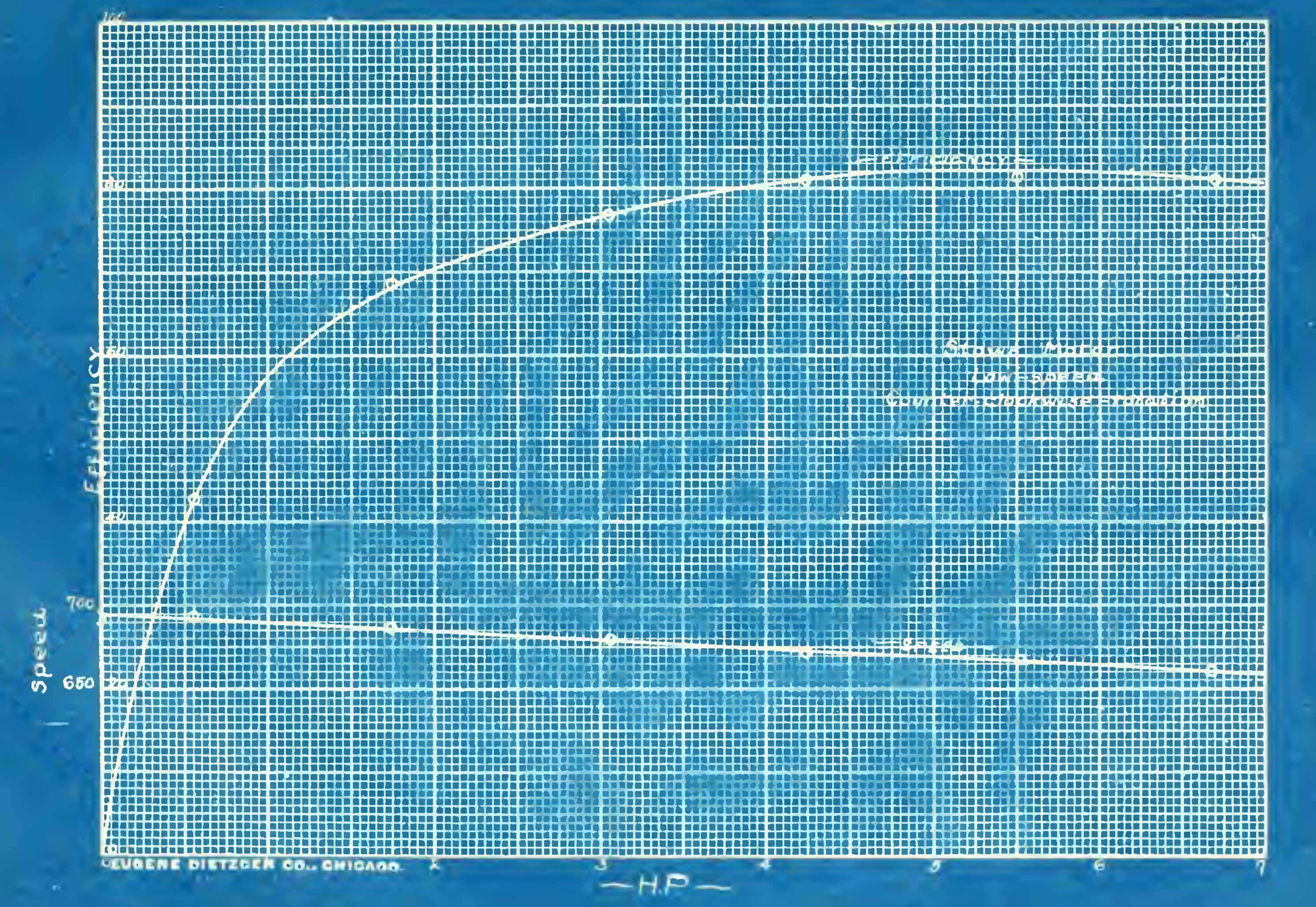

Stowe Motor
Low Speed
Clockwise rotation
Efficiency
Speed
Efficiency
Speed
H.P.
100
80
60
40
20
0
700
600
500
2
3
4
5
6
7
EUGENE DIETZGEN CO., CHICAGO.

Stowe Motor

Low Speed — Counter Clockwise Rotation.

Ia.	If.	Watt Input	Speed	Wt.	H.P.	Eff.
2.8	1.45	467	695	0.	0.	0.
7.5	1.45	984	687	2.03	.504	47.5
15.6	1.45	1875	680	6.6	1.71	68.
25.5	1.45	2964	675	11.6	2.93	75.
35.0	1.42	4007	665	16.6	4.2	75.[illegible]
45.0	1.45	5107	658	21.6	5.41	79.2
54.0	1.45	6099	658	26.6	6.63	81.6
65.0	1.45	7309	650	31.6	7.82	79.8
76.3	1.45	85.52	645	36.6	8.98	77.[illegible]
6.	1.45	819	699	1.6	4.026	53.9
15.5	1.45	1864	686	6.6	1.725	69.[illegible]
24.7	1.45	2876	680	11.6	3.0	77.5
34.	1.45	3899	675	16.6	4.27	81.8
44.6	1.42	5662	669	21.6	5.50	81.2
54.9	1.42	61.05	658	26.6	6.36	80.5
68.	1.42	7336	658	31.6	7.32	77.5
75.4	1.42	8450	650	36.6	9.05	80.[illegible]
7.5	1.42	981	709	2.2	.59	45.[illegible]
16.0	1.42	1916	693	6.6	1.74	67.6
25.	1.42	2906	686	11.6	3.30	77.7
36.0	1.42	3985	680	16.6	4.3	80.[illegible]
44.8	1.42	5034	675	21.6	5.55	81.[illegible]
56.1	1.41	6326	665	26.6	6.73	79.4
68.8	1.41	7725	650	31.6	7.22	75.[illegible]
79.4	1.41	8889	659	36.6	8.00	74.[illegible]

E=110 Volts.


Stowe Motor
Low speed
Counter-Clockwise rotation
Efficiency
Speed
Efficiency
Speed
700
650
100
80
60
40
20
2
3
4
5
6
7
—H.P—
EUGENE DIETZGEN CO., CHICAGO.

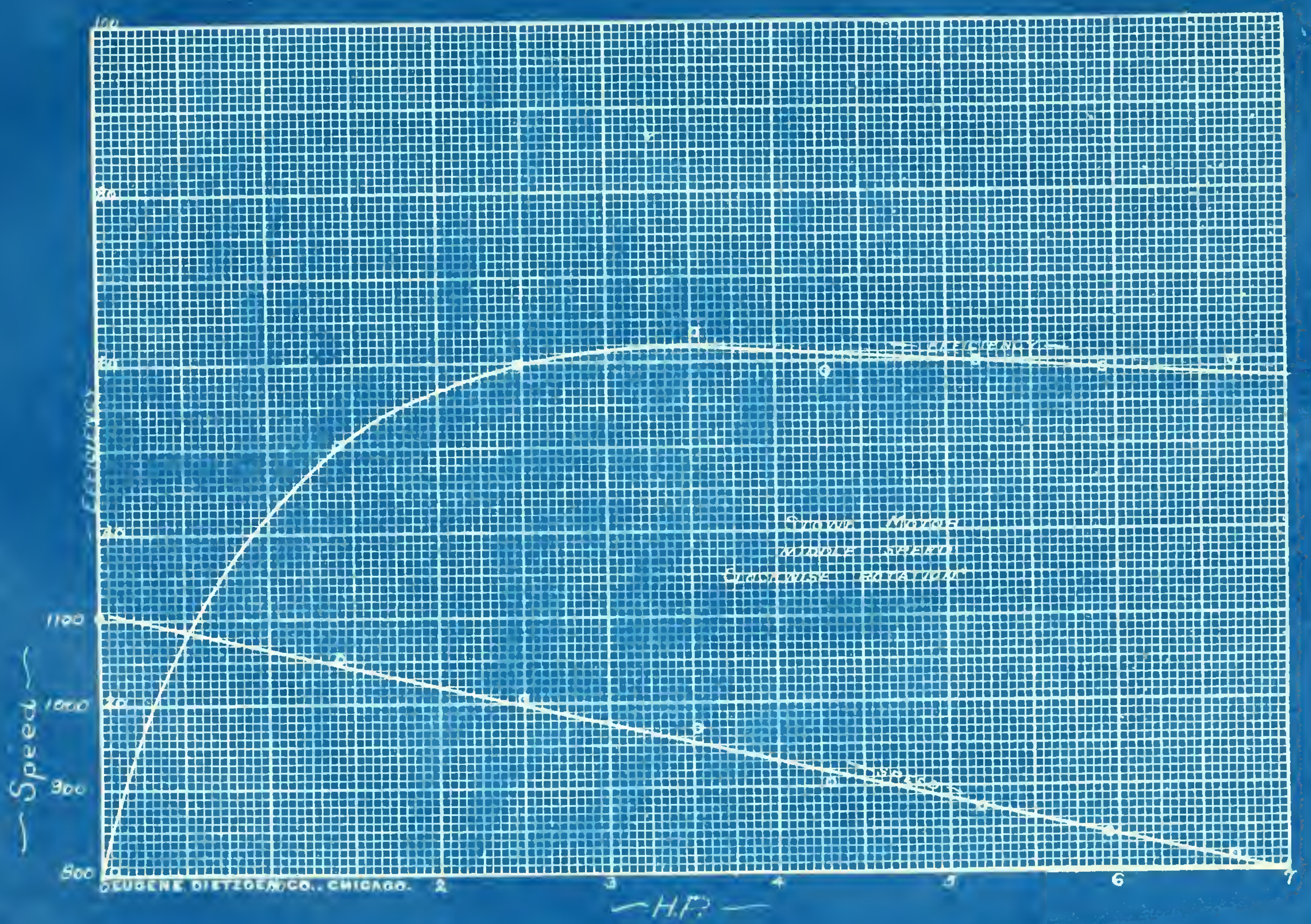
Stone Motor.

Middle Speed. Clockwise Rotation.

Ia.	If	Watt Input	Speed	Wt.	H. P.	Eff.
7.9	1.32	1003	1105	0.	0.	0.
15.8	1.32	1893	1032	1.5	.51	[illegible]
18.7	1.31	2201	1051	3.5	1.41	[illegible]
27.6	1.31	3180	1009	6.5	2.40	[illegible]
37.1	1.31	4225	973	9.5	3.52	[illegible]
49.8	1.31	5622	895	12.5	4.26	[illegible]
57.0	1.31	6414	877	15.5	5.18	60.3
66.5	1.31	7350	847	18.5	5.97	[illegible]
75.0	1.31	8394	813	21.5	6.69	59.6

14.8	1.32	1773	1062	1.7	.59	[illegible]
16.4	1.32	1949	1051	3.5	1.4	53.7
26.6	1.32	3071	1002	6.5	2.48	60.5
35.7	1.32	4072	967	9.5	3.5	64.2
46.8	1.31	5292	913	12.5	4.35	61.3
57.3	1.31	6447	871	15.5	5.15	59.7
68.0	1.31	7624	835	18.5	5.89	57.6
74.4	1.31	8328	816	21.5	6.32	56.8

E-- 110 Volts.


Motor
Middle Speed
Clockwise Rotation
Efficiency
Speed
— Speed —
1100
1000
900
800
— H.P. —
2
3
4
5
6
7
EUGENE DIETZGEN CO., CHICAGO.

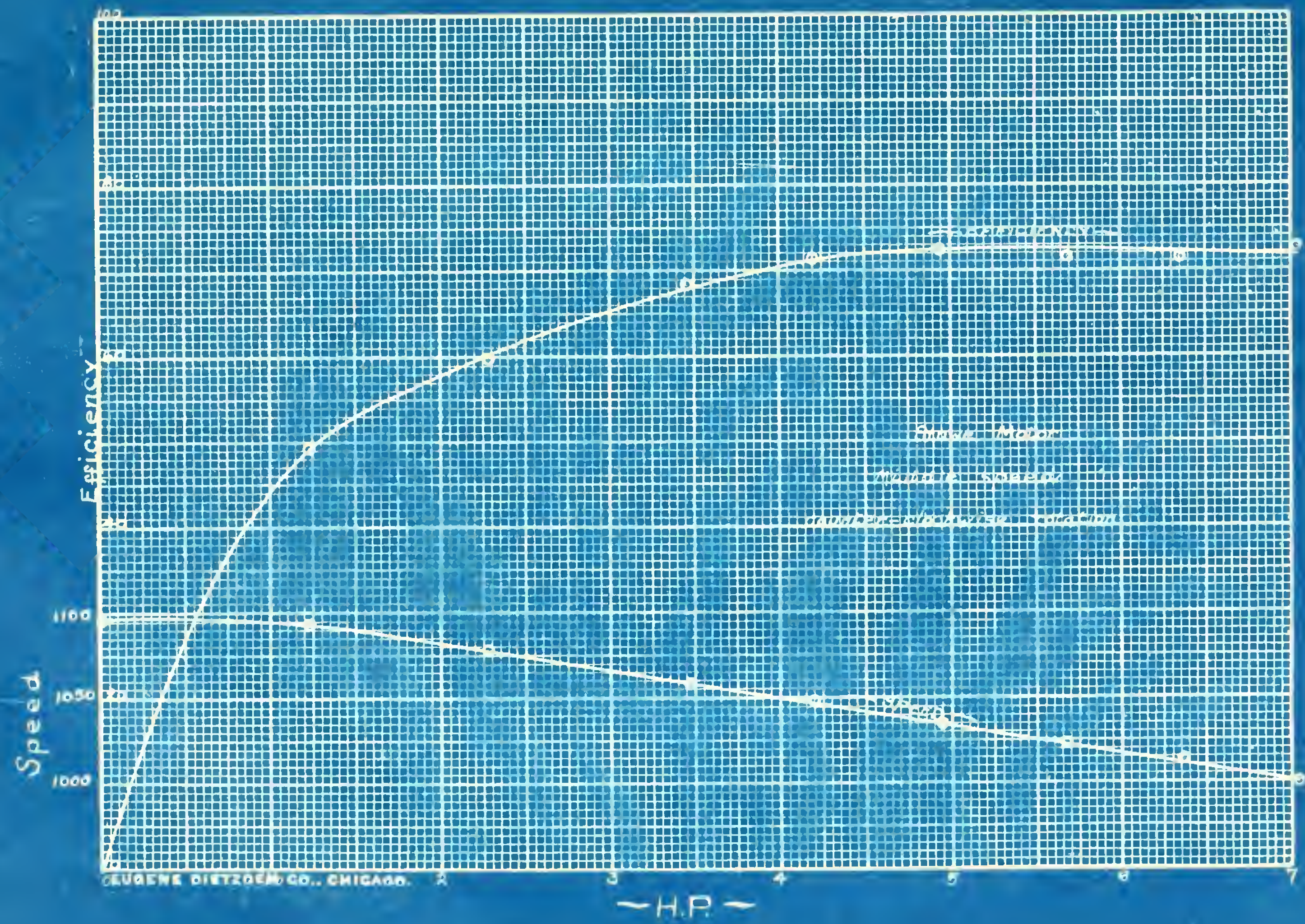
Stowe Motor

Middle Speed Counter Clockwise Rotation.

Ia	If.	Watt Imput	Speed	Wt.	H. P.	Eff.
5.7	1.45	786	1095	0	0	0
15.5	1.45	1364	1095	3.0	1.33	50.
24.7	1.42	1873	1089	5.6	2.32	70.5
33.6	1.41	3851	1070	8.6	3.5	67.9
39.3	1.41	4478	1062	10.6	4.28	71.5
45.8	1.41	5193	1050	12.6	5.04	72.6
54.4	1.41	6139	1042	14.6	5.8	70.5
60.0	1.41	6755	1030	16.6	6.51	72.0
65.7	1.41	7382	1018	18.6	7.22	73.05
81.2	1.41	9087	970	22.6	8.35	68.7

6.6	1.41	881	1095	0	0	0
16.6	1.41	1981	1070	3.15	1.28	48.3
2.41	1.41	2906	1048	5.6	2.25	59.4
32.2	1.41	3697	1036	8.6	3.39	68.7
37.7	1.41	4302	1021	10.6	4.12	71.4
45.1	1.41	5116	1006	12.6	4.84	70.6
50.8	1.41	5743	1000	14.6	5.56	72.3
58.1	1.41	6546	981	16.6	6.20	70.8
63.6	1.41	7151	976	18.6	6.91	72.00
71.6	1.41	8031	963	20.6	7.55	70.2

E--110 Volts.


Efficiency
Speed
1100
1050
1000
EUGENE DIETZGEN CO., CHICAGO.
2
3
4
5
6
7
~H.P.~
Efficiency
Speed
Single Motor
counter-clockwise rotation

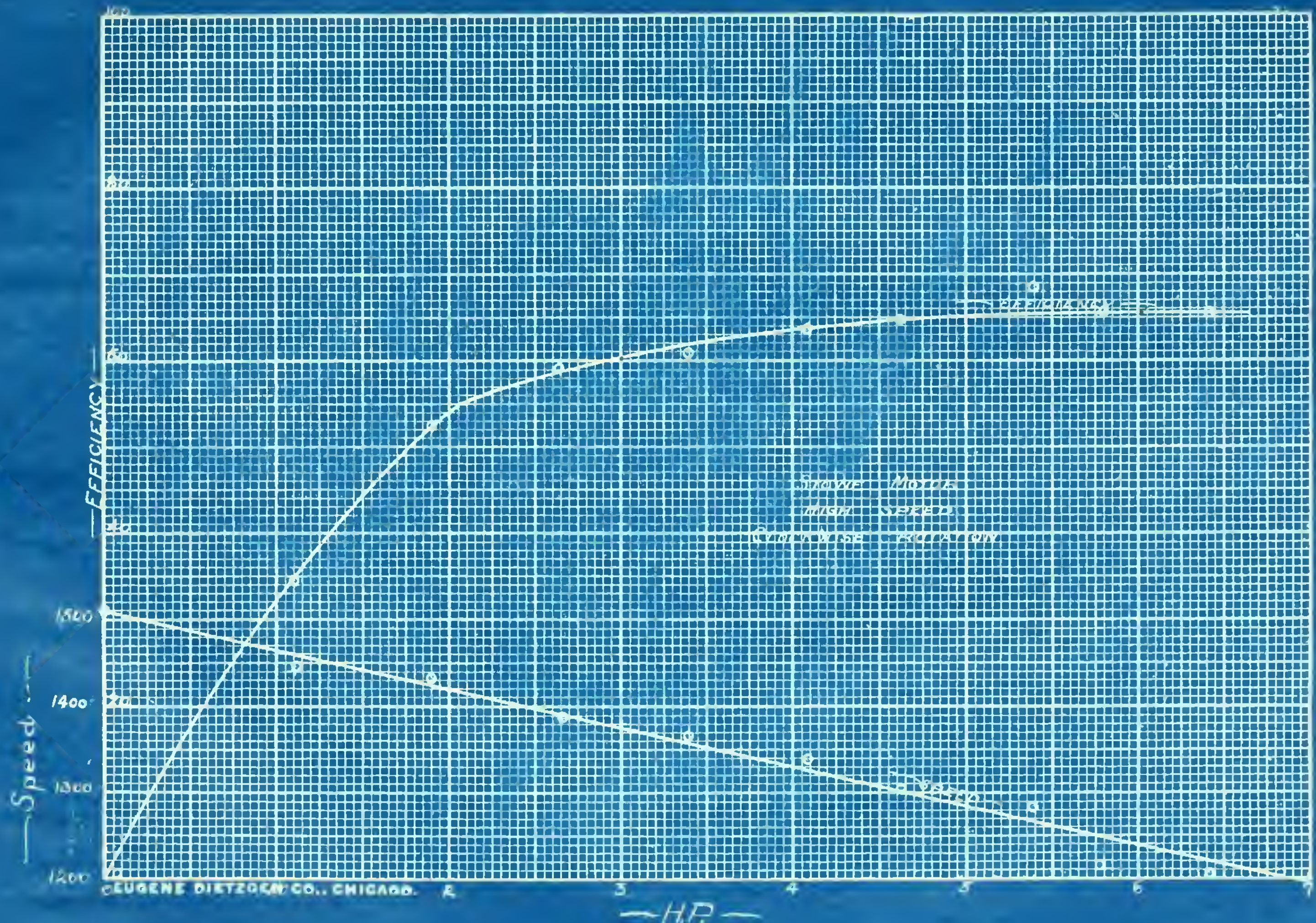
Stowe Motor.

High Speed Clockwise Rotation.

Ia.	If.	Watt input	Speed	Wt.	H. P.	Eff.
13.1	1.33	1477	1510	0.	0.	0.
21.5	1.32	2510	1460	2.0	1.08	[illegible]
23.8	1.32	2735	1409	3.5	1.37	50.6
31.7	1.32	3652	1335	5.0	2.60	[illegible]
35.7	1.31	4071	1330	6.5	3.37	63.6
42.9	1.31	4865	1325	8.0	4.04	62.0
47.9	1.31	5413	1282	9.5	4.34	[illegible]
50.9	1.31	5743	1282	11.0	5.37	70.0
59.7	1.31	6711	1225	12.5	5.82	65.0
66.2	1.31	7423	1211	14.0	6.43	65.0

Ia.	If.	Watt input	Speed	Wt.	H. P.	Eff.
13.6	1.33	1532	1510	0.	0.	0.
19.7	1.33	2315	1474	2.0	1.12	[illegible]
22.8	1.31	2652	1457	3.5	1.94	[illegible]
27.6	1.31	3180	1409	5.0	2.68	[illegible]
37.1	1.31	4225	1373	6.5	3.4	60.0
41.3	1.3	4683	1354	8.0	4.13	65.7
48.8	1.3	5511	1325	9.5	4.7	[illegible]
53.0	1.3	5973	1289	11.0	5.40	67.5
58.1	1.3	6534	1200	12.5	5.72	[illegible]
64.1	1.3	7194	1195	14.0	6.37	[illegible]

E = 110 Volts.

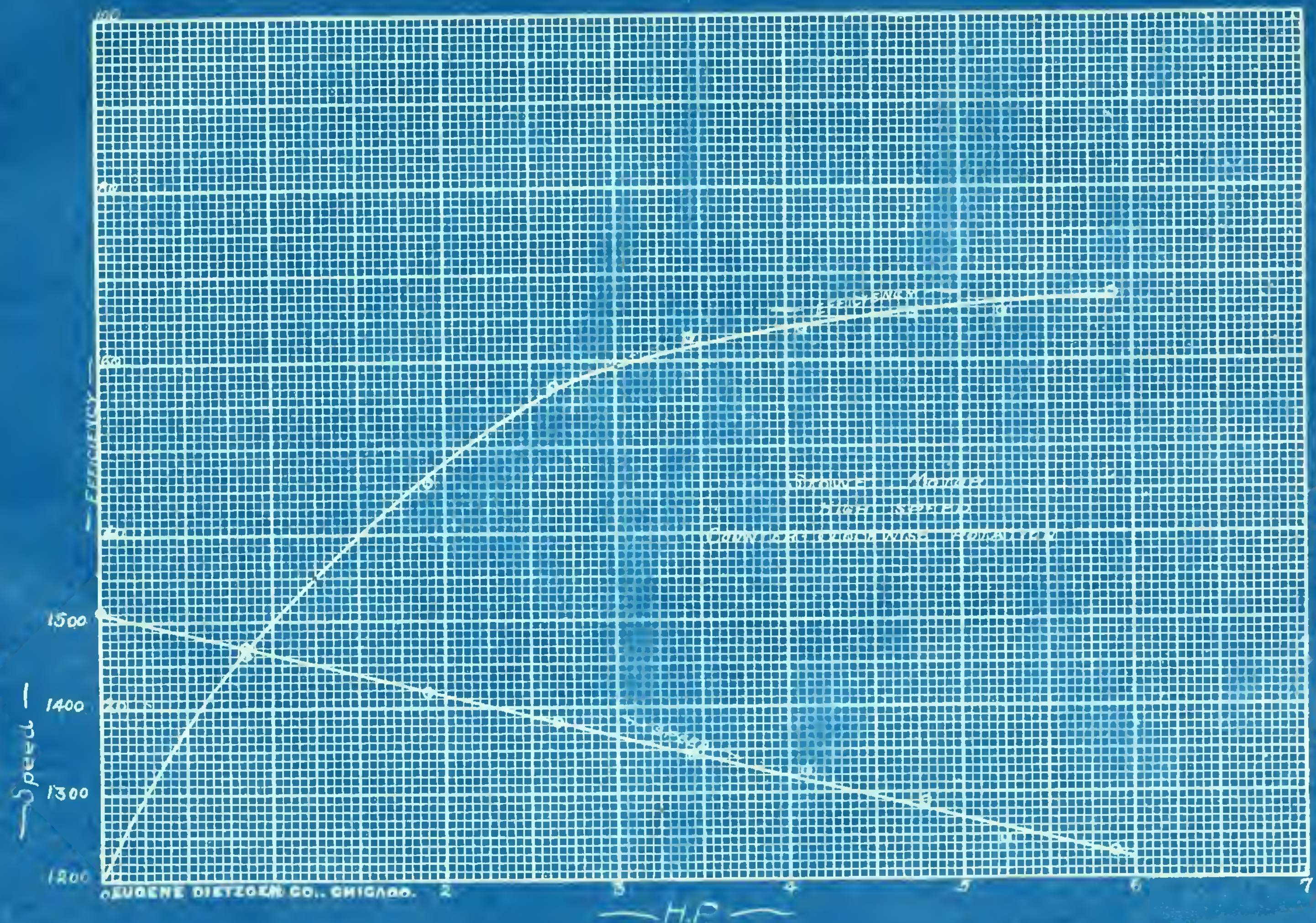


Stowe Motor
High Speed
Clockwise Rotation
Efficiency
Speed
Efficiency
Speed
1500
1400
1300
1200
2
3
4
5
6
7
H.P.
EUGENE DIETZGEN CO., CHICAGO.

Stowe Motor.

	High Speed		Counter Clockwise Rotation.			
Ia.	If.	Watt Input	Speed	Tt.	H.P.	Eff.
12.0	1.4	1474	1510	0.	0.	0.
20.1	1.4	2365	1474	2.	1.125	[illegible]
23.7	1.4	2761	1432	3.5	1.35	52.7
33.0	1.39	3732	1421	5.1	2.73	[illegible]
38.8	1.39	4420	1391	6.5	3.45	[illegible]
45.6	1.39	5102	1356	8.1	4.1[illegible]	[illegible]
48.7	1.39	5502	1358	9.5	4.35	[illegible]
54.0	1.38	6091	1302	11.0	5.52	[illegible]
60.6	1.38	6317	[illegible]	12.5	5.95	[illegible]
[illegible]	[illegible]	1543	1510	0.	0.	0.
[illegible]	[illegible]	2507	1432	1.5	.64	37.
25.6	1.38	2967	1421	3.5	1.9	45.7
30.1	1.37	3461	1383	5.0	2.64	[illegible]
35.7	1.37	4077	1347	6.7	3.43	[illegible]
42.3	1.37	4303	1323	8.1	[illegible]	[illegible]
47.3	1.37	5356	1300	9.6	4.72	[illegible]
52.9	1.37	[illegible]	1248	11.0	5.24	[illegible]
57.3	1.37	6508	1230	12.5	5.36	[illegible]

E-- 110 Volts.


Series Motor
High Speed
Counter Clockwise Rotation
Efficiency
Speed
H.P.
1500
1400
1300
1200
2
3
4
5
6
7
EUGENE DIETZGEN CO., CHICAGO.

Stone Motor.

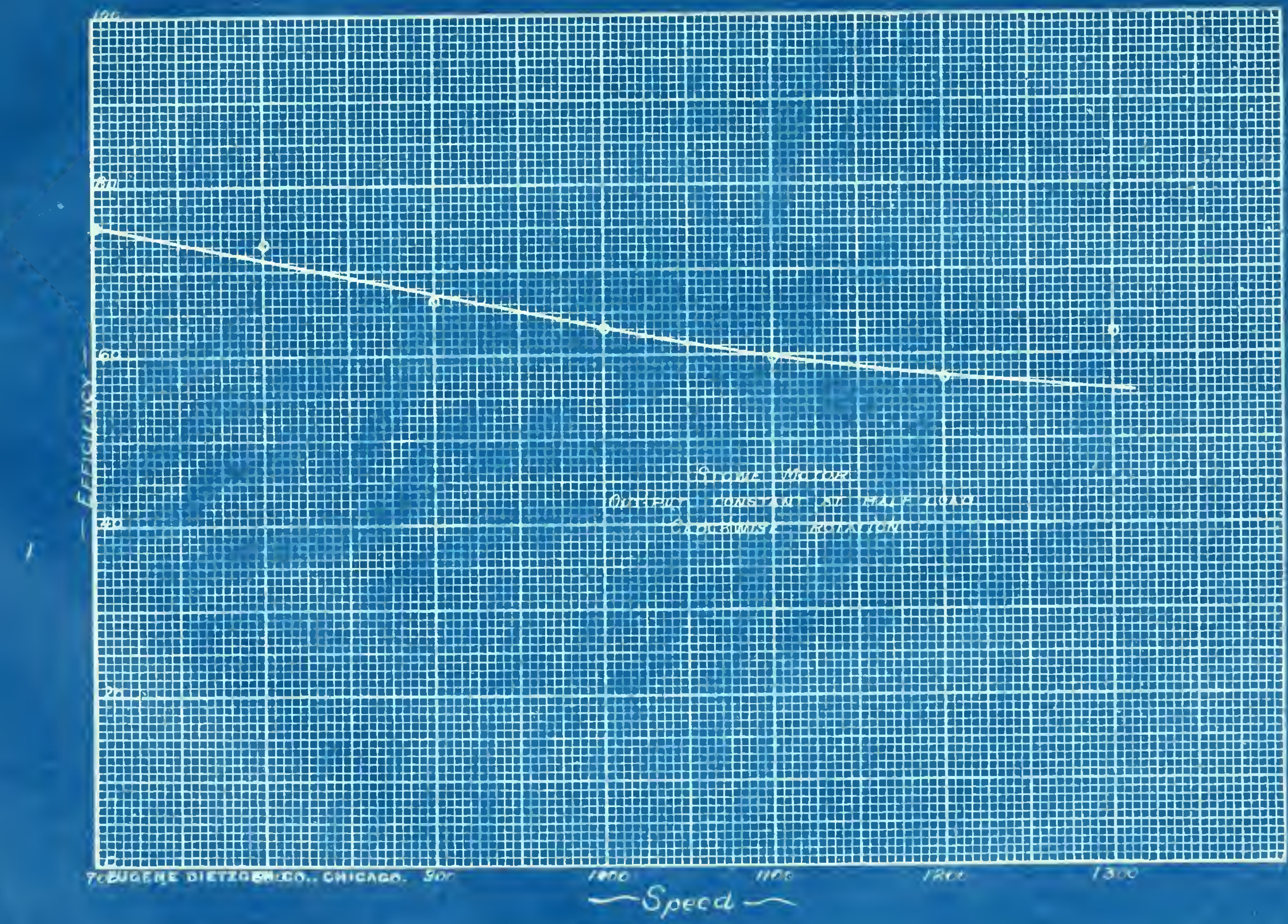
Half Load (Constant) Clockwise Rotation.

Ia.	If.	Watt Imput	Speed	[illegible] T.	H. P.	Eff.
25.7	1.37	2977	700	11.25	3.	75.2
26.5	1.36	3042	800	9.[illegible]	3.	[illegible]
29.2	1.36	3361	900	8.75	3.	[illegible]
30.9	1.36	3543	1000	7.87	3.	[illegible]
33.1	1.36	3700	1100	7.15	3.	[illegible]
34.2	1.36	3911	1200	6.55	3.	57.7
31.0	1.36	3559	1300	6.05	3.	[illegible]

Half Load Constant Counter Clockwise Rotation.

Ia.	If.	Watt Imput	Speed	[illegible] T.	H. P.	Eff.
26.3	1.36	3042	700	11.25	3.	[illegible]
26.9	1.35	3107	800	9.35	3.	70.[illegible]
25.9	1.35	3107	900	8.75	3.	70.3
28.0	1.34	3227	1000	7.87	3.	[illegible]
30.6	1.34	3513	1100	7.15	3.	[illegible]
34.6	1.34	3955	1200	6.55	3.	56.5
36.3	1.34	4195	1300	6.05	3.	[illegible]
37.7	1.34	4204	1400	5.62	3.	52.[illegible]

E—- 110 Volts.



100
80
60
40
20
0
Efficiency
Stone Motor
Output constant at half load
Clockwise rotation
700
EUGENE DIETZGEN CO., CHICAGO.
900
1000
1100
1200
1300
Speed

Stowe Motor

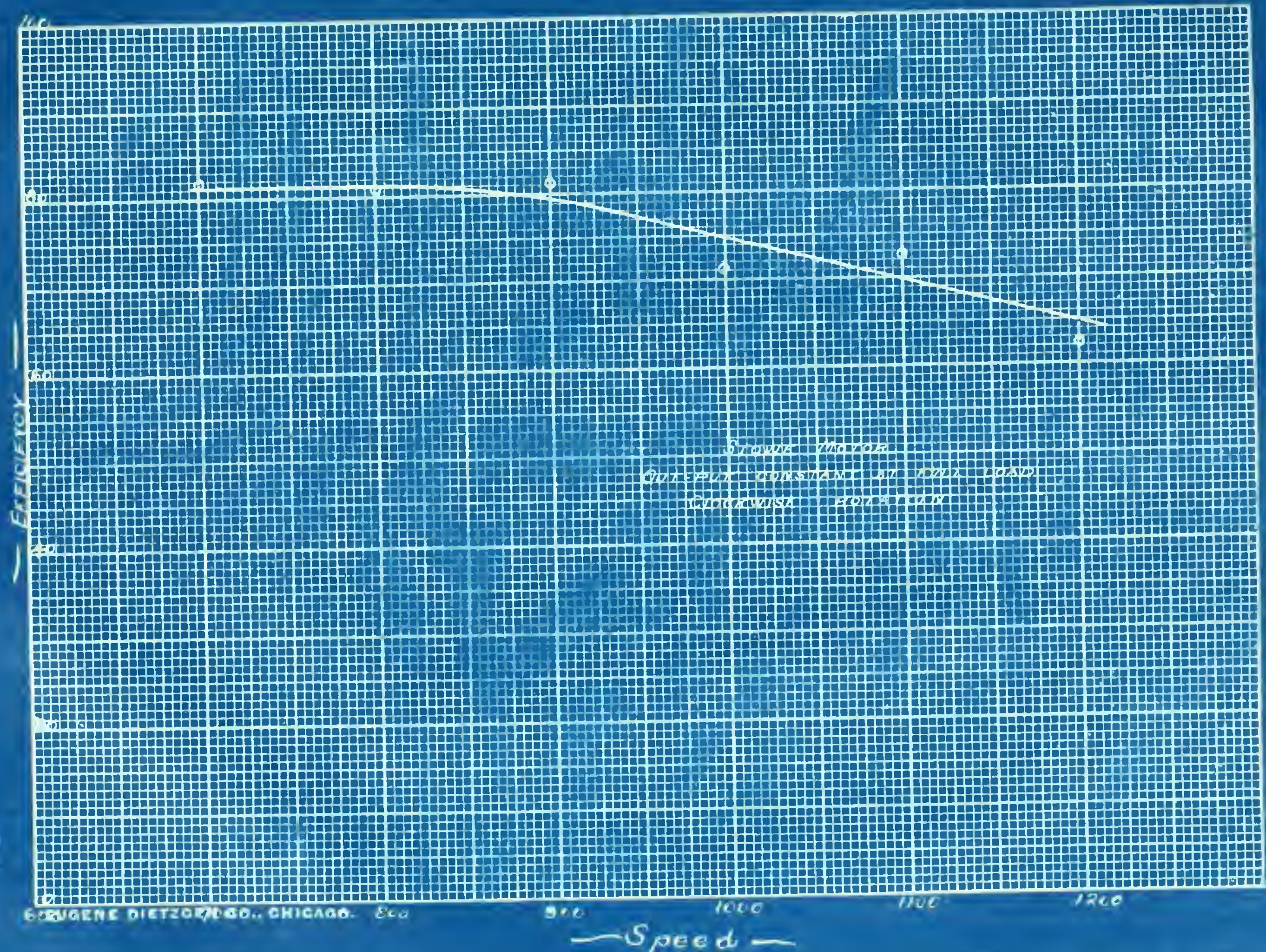
Full Load (Constant) Clockwise Rotation.

Ia.	If.	Watt Input	Speed	Wt.	H. P.	Eff.
47.9	1.37	5464	700	22.5	6.	[illegible]1.[illegible]
49.4	1.37	5584	800.	19.7	6.	[illegible].[illegible]
47.9	1.37	5464	900	17.5	6.	[illegible].[illegible]
55.8	1.37	6288	1000	15.74	6.	71.[illegible]
53.8	1.37	6068	1100	14.3	6.	73.[illegible]
63.6	1.35	7144	1200	13.1	6.	62.7

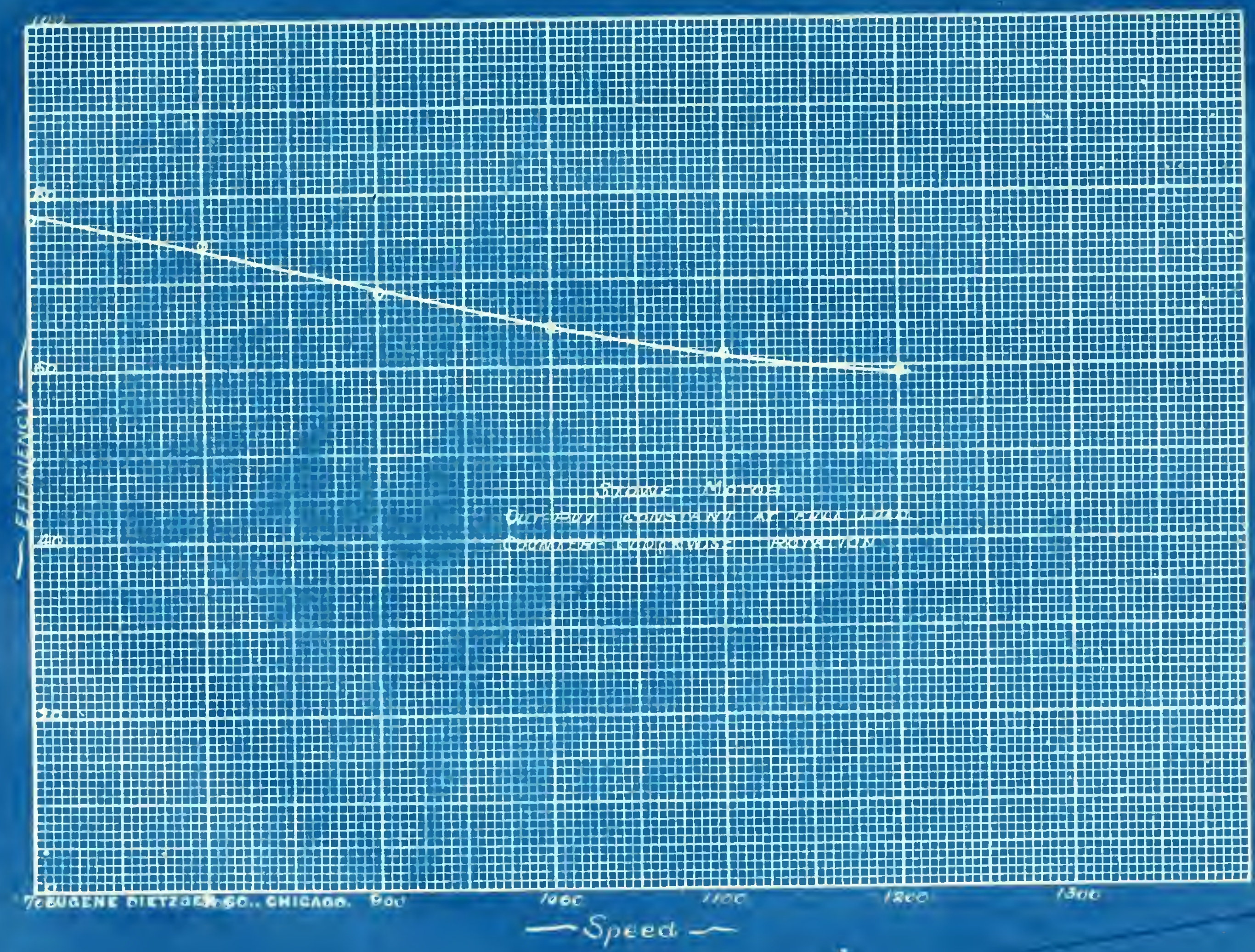
Full Load (Constant) Counter Clockwise Rotation.

Ia.	If.	Watt Input	Speed	Wt.	H. P.	Eff.
51.	1.4	5764	700	22.5	6.	77.[illegible]
53.3	1.39	6015	800	19.7	6.	74.4
57.9	1.38	6520	900	17.5	6.	68.[illegible]
62.1	1.37	6981	1000	15.74	6.	64.[illegible]
65.0	1.36	7299	1100	14.3	6.	[illegible]1.4
67.0	1.35	7518	1200	13.1	6.	5[illegible].5

E-- 110 Volts.



Stowe Motor
Out-put constant at full load
Clockwise rotation
Efficiency
100
80
60
40
20
0
800
900
1000
1100
1200
Speed
Eugene Dietzgen Co., Chicago.



Motor
Output constant at full load
100
80
60
40
20
Efficiency
Eugene Dietzgen Co., Chicago.
900
1000
1100
1200
1300
Speed

DISCUSSION OF RESULTS.

The interpole [illegible] was increased to 1000 [illegible]. [illegible] slight sparking occurred. It was impossible to [illegible] the test on the Stow and Lincoln [illegible] because of their mechanical construction, which allowed only a slight increase above the rated speed. Excessive sparking occurred in these at speeds above 1000 r. p. m. [illegible] at high speed and full rated load.

Consideration of the [illegible] will make it [illegible] why the [illegible] is [illegible] tendency to sparking.

When a brush is in contact with two adjoining commutator-segments the coil connected between said segments is short-circuited on itself. The resistance of the short-circuited coil, together with the connections to the commutator, being very small as compared with the contact resistance of the brush pressing on the commutator, the strength of the currents flowing toward the brush from the respective commutator-segments will, to a great extent, be dependent upon the relative value of the contact resistance, and the larger the latter the smaller will be the currents. This quality of the carbon brush tends to prevent sparking.

As the short-circuited coil passes under the brush, the current flowing in it is reversed, passing from the maximum in one direction down to zero, and then up to the maximum in the opposite direction. The current thus varying in the coil short-circuited between said brushes generates in the coil an electromotive force tending to maintain the said varying current. The effect, therefore, of self-induction is to produce sparking.

The current flowing through the different armature coils produce a magnetic field in the space between the pole pieces — that is, in the region of the coils that are being short-circuited.

These coils in their rotation, cut the lines of force of the field, and an E. M. F. is thereby generated in them. This E. M. F. is in such a direction that it tends to maintain the current flowing in the coil. The effect, therefore, of armature reaction is to produce sparking.

In the constant speed motor the two main causes of sparking are self induction of the short-circuited coil, and the action of this coil in generating or maintaining E. M. F. by cutting the field of the armature. They are overcome in part by the resistance of the brush contact as mentioned above, and also by so placing the brushes that the short-circuited coil is in the edge of the main magnetic field. When properly placed the coil cuts lines of force in such a manner that the E. M. F. generated aids in the reversal of the current — that is, the main field is used to prevent the lines of force from the armature

field remains, but in the region of the short circuited coil.

While it is possible in the constant speed motor to control the sparking by the [illegible] alone, this method is entirely inadequate for the variable speed motor. The reduction of the field of strength necessary to obtain the high speeds, prevents its use in overcoming the magnetic field of the armature. The armature field is, therefore, not only present, but the increased speed of the armature proportionally increases the maintaining E. M. F. until it becomes so large that the carbon brush cannont overcome it. The increased speed of the armature also increases the E. M. F. of self-induction. As a result it becomes impossible for the carbon brush to reverse the current in the short-circuited coil, and in consequence there is destructive sparking at the high speeds. In order, therefore, to control the E. M. F. it is necessary to provide a magnetic field independent of the main field of the motor. This is done in the interpole motor by auxiliary poles, which are small compared with the main poles, and are located between the latter and provided with coils connected in series with the armature, so that all of the current flowing in the latter flows through the coils of the auxiliary poles, and [illegible] the commutation. As the coils of the auxiliary poles are connected in series with the armature, [illegible]

[illegible] ,
auxiliary pole [illegible] the [illegible]
commutation [illegible] field, [illegible]-
creased number of [illegible] -
[illegible] produce [illegible], the [illegible]
the auxiliary pole [illegible],
[illegible] the [illegible], because [illegible]
[illegible] in the auxiliary [illegible].

[illegible] similar [illegible]
[illegible] load.

1, [illegible] rotation: [illegible] -
[illegible] regulation curves.

For the [illegible] of 34% [illegible] remained practically constant from half to full load. The speed regulation was 3.0-3% from no to full load. The speed [illegible] load.

The [illegible] its highest efficiency at full load, reaching 80%. The [illegible] full load [illegible] 70% [illegible]. The [illegible] was 10.5-4% from no to full load, the [illegible] varying in a straight line.

The [illegible] its highest efficiency [illegible] being 74%. [illegible] full load the efficiency was 70%. The [illegible] regulation was 20% from no to full load, [illegible] directly as the load.

2. [illegible] speed, counter clockwise rotation; same curves as (1).

For the interpole the efficiency [illegible] 83% [illegible] and remained practically constant from half to full load. The speed regulation was [illegible]% from zero to full load, the curve being a straight line variation.

The Lincoln motor gave its highest efficiency at full load being 80.8% after which it drops rapidly. The speed regulation was 2.3-4% from zero to full load: the curve being a straight line.

The Stow gave an efficiency of 82% at full load, after which it dropped gradually. The speed regulation was 4.5% from zero to full load.

3. Middle speed, clockwise rotation: same curves as in (1).

For the interpole the maximum efficiency was reached at about half load being [illegible].5%. From here it dropped gradually to 78.5% at full load. The speed dropped until half load was reached, then it rose to almost its normal value. The widest variation at half load was 4%.

The Lincoln motor efficiency increased gradually to [illegible]% at full load and remained practically constant to 50% over-load. The speed regulation was [illegible]% from zero to full load: the curve being a straight line.

The efficiency of the [illegible] about half load [illegible] 80%. [illegible] it decreased to 50% at full load. The speed regulation was 23% from zero to full load, [illegible].

4. [illegible], [illegible] rotation: [illegible] in ([illegible]).

For the [illegible] the efficiency [illegible] at [illegible] full load, being 75.5%. [illegible] to 74% at full load. The speed regulation [illegible], the [illegible] being 9%, at about half load.

The Lincoln motor's efficiency rises gradually from 70% at half a maximum of 77.5 at 50% overload. The efficiency at full load was 73.5%. The speed regulation was 8.5% from zero to full load, the variation being in a straight line curve.

In the Stow the efficiency is a maximum at full load being 72.8%. The efficiency at light loads was rather poor, that at a quarter load being 53%. The speed variation was in a straight line curve, the regulation being 9%.

5. High speed, clockwise rotation: curves as in (1).

On the interpole the efficiency reaches its maximum at about half load, being 77.5%, gradually decreasing till at half load it is 75%. The efficiency at light loads are good, a quarter load being 72.5%. The speed regulation was 4.5%, the speed varying with the load to half load after which it was constant.

The efficiency for the Lincoln motor was 77.5% at half load, 70% at full load and at 50% overload 71.5%. The speed regulation was 8% from zero to full load.

The Stow gave an efficiency of 30% [illegible] full load. The speed regulation was 22.5% from zero to full load; the curve being a straight line.

6. High speed counter clockwise rotation: curves [illegible] (I)

In the Interpole the efficiency at quarter load was 77%, at half load 81% and at full load 80%. The speed regulation was 4.5% from zero to full load, the curve being a straight line.

The efficiency of the Lincoln motor was 59% at quarter load, 35% at half and from there constant to 50% overload. The speed regulation was 13%, the speed varying with the load.

In the Stow the efficiency at quarter load was 25%, at half load 50.3% and at full load 67.5%. The speed regulation was 10% from zero to full load; there being a straight line variation between load and speed.

7. Variation in efficiency with speed, the load constant at full load: clockwise rotation.

On the interpole motor the full load efficiency ran from 33.5% at 100 revolutions per minute to 75.5% at 1100 r.p.m. The curve is a straight line on the lower speeds, starts to droop at a little above half speed and drops rapidly at the higher speeds.

The efficiency of the Lincoln motor ran from 37.5% at 300 r.p.m. to 77.5% at 1450 r.p.m. The variation followed a straight line.

The Stow had an efficiency of 23% at 700 r.p.m. and 35% at

1200 r.p.m. The speed was 700 r.p.m. [illegible] [illegible] ob [illegible]

8. Variation in efficiency with speed, [illegible] at full load, [illegible] rotation.

The efficiency [illegible] 64.5% at 700 R.p.m. to 73.5% at 1200 r.p.m. The efficiency varies with the speed, there being a straight line variation.

The [illegible] efficiency varies [illegible] at 700 r.p.m. to 70% at 1200 r.p.m. The curve is slightly [illegible], the efficiency [illegible] function of the speed.

The variation of the St[illegible] from 77.5% at 700 R.p.m. to 59% at 1200 r.p.m. The variation follows a [illegible] line until the [illegible] speed, [illegible] with an increase of speed.

9. Comparison of efficiency with speed, [illegible] at full load, [illegible] rotation.

The [illegible] efficiency of 84.5% at 700 r.p.m. and 93.5% at 1100 r.p.m. The efficiency increases [illegible] until about [illegible] it reaches [illegible] -ciency.

The [illegible] gives an efficiency [illegible] at 700 R.P.M. and 73.5% at 1200 R.P.M. The variation [illegible] line.

In the St[illegible] efficiency [illegible] at 700 R.P.M. and [illegible] at 1200 r.p.m. The variation [illegible] line.

light loads, while the other gives a [illegible] efficiency at light loads.

An example of this variation [illegible] the curves, thus:

Low speed, clockwise rotation.

load.	Interpole	Lincoln	Stow.
1-4	75%	34.5%	61%
1-2	82.2	74.5	72
3-4	84	79	73
full	83.8	81	72.

Another striking variation can be seen from the high speed, clockwise rotation curves.

load.	Interpole	Lincoln	Stow.
1-4	72.5%	50%	44%
1-2	73.4	67.5	60.5
3-4	78.2	69.3	64.7
full	75.5	70.	65.5

The [illegible] of the machines [illegible] seen from the regulation, clockwise rotation curves.

	Interpole.	Lincoln.	Stow.
[illegible]	3.5-4%	10.2-3%	20%
High speed	4.1-2%	[illegible]%	20.5%

Another table will show the variation of efficiency with speeds.

Full load	Interpole	Lincoln	Stow.
Low speed	83.5%	87%	81%
High	73%	70%	35%

The speed range of the Interpole is 4 to 1, of the Lincoln 5 to 1, and of the Stow 3 to 1. [illegible] the interpole [illegible] increased under full load. [illegible] value, giving a speed range of 3 to 1. The [illegible] of the Lincoln motor under full load gave a range of 4½ to 1. The Stow motor under full load gave a range of 1½ to 1.

All of the machines are compact, and require no outside accessories, although there is a marked difference in their mechanical construction. The interpole is of simple design, while the Lincoln and Stow, especially the former, possess a very complicated mechanical construction to obtain variable speed control.

As a result of our tests and observations we found the Interpole motor superior to the Lincoln and Stow from the standpoints of high efficiency under average loads, [illegible]

tion, non-sparking under excessive loads, simple mechanical construction, and therefore conclude that the method of variable speed control, as embodied in the Interpole motor, is the best.